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[FOURTH SERIES.]

Art. XII. — *Magnetic Field and Coronal Streamers;* by John Trowbridge.

In the course of an investigation of the phenomena presented by electric discharges in strong magnetic fields, it was soon apparent that phenomena appear at high voltages together with strong steady currents which do not manifest themselves at lower voltages and lesser currents. I have, therefore, employed comparatively large tubes; voltages ranging from 3000 to 8000 between the discharge terminals; currents from 5 milliamperes to 20 milliamperes.

The most practical form of resistance I have used is a column of running tap water under constant pressure in glass tubes of suitable diameter. Graphite resistances mounted on quartz have a large temperature-coefficient, and also a remarkable counter electromotive force. The glass tubes containing rarified air ranged from cylindrical tubes 30^{cm} long, 4^{cm} internal diameter to cylindrical tubes 48^{cm} long and 10^{cm} internal diameter. The experiments described in this paper were performed with tubes 30^{cm} long and 4^{cm} internal diameter.

At pressures varying from 1^{cm} to 1^{mm} the cathode light on a circular aluminum plate 3^{cm} in diameter forming the pole of a powerful magnet, the magnetic lines of which are directed along the line of electric discharge, is driven to the circumference of the disc, forming to the eye an apparently steady circular discharge. When the tube, however, is covered with black paper, exposing only the light of the disc, and this light is examined in a revolving mirror, it is seen that we have an interesting case of unipolar rotation. Fig. 1 is a photograph taken of the reflection in the revolving mirror. The glass

walls of the tube and the necessary obliquity in the reflection modify the sharpness of the image. The speed of revolution increases with the degree of exhaustion of the rarified air. When the free path of the ions increases, the progressive effect along the magnetic lines becomes more than the rotational effect of the magnetic field. When the plate forms the anode and also the end of a magnetic pole the lines of magnetic force being directed along the line of electric discharge, the light at the anode is separated into two distinctly different lights; one (in rarified air), a plume-like rosy light, the other a plume-like violet light. These discharges also revolve around the pole near the center of the disc instead of on the circum-

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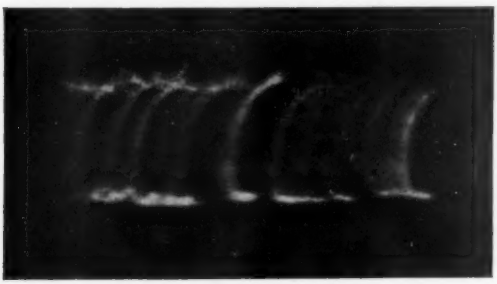

ference, as in the case of the cathode disc. On account of the number of individual discharges on the anode it is difficult to follow their motions in a revolving mirror or by the eye, or to photograph them. It is certain, however, that they revolve about the pole.

The unipolar rotation which I have described leads my mind to connect the phenomenon of coronal streamers seen at the poles of the sun in an eclipse, with the effect of a magnetic field on possible electrical discharges between the equatorial regions of the sun and the poles of the sun. If we suppose that a difference of electrical potential can arise between the swiftly moving strata of gases or from the eruptions which take place mainly along the equatorial belt and the polar regions, the supposed magnetic poles of the sun would undoubtedly tend to cause the resulting electric discharges to revolve about the pole. On account of the vast circumferential area about the poles a number of discharges could occur at different points around the pole and each discharge would revolve under the effect of the pole. In observing the effect of a strong magnetic pole on plate terminals in wide tubes of rarified air, at comparatively high pressure of air under conditions of high

electromotive force and great current density, one can observe phenomena of rotation which cannot be photographed yet which present to the eye a strong analogy to the appearance of coronal streamers.

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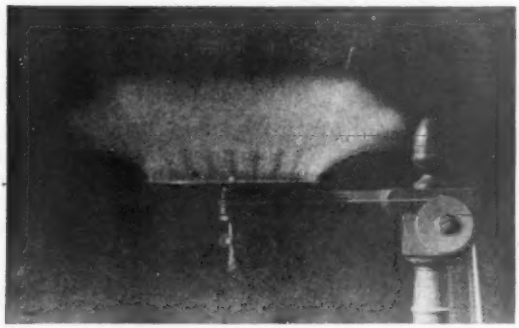

I arranged a number of collections of bristles on a disc which was then set in rapid rotation. Fig. 2 is a photograph of the appearance of such revolving streamers, which repre-

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sent fairly well what may be seen at the terminal of a discharge tube in a magnetic field.

There is, however, another magnetic phenomenon which may have a bearing upon the coronal streamers at the poles of the sun. When the lines of magnetic force are at right angles, or transverse to the direction of the electric discharge, at comparatively high pressures, one to two centimeters, with currents

from 5 to 20 centimeters, 3000 to 8000 volts in wide tubes, streamers radiate from the position of the magnetic pole. Fig. 3 is a photograph of such streamers or stratifications. It will be noted that these striæ make their appearance at a much higher pressure than that of the usual striæ in rarified gases.

Electric discharges around or toward the poles of the sun transverse to the lines of magnetic poles of the sun could be separated into streamers.

Effect of a Magnetic Field on the Production of X-Rays.

The ordinary form of X-ray bulb does not lend itself easily to the application of the magnetic field, either at the anode or the cathode, and even in the special form of bulb, fig. 4, which I have used in this investigation, it was not possible to develop magnetic lines of force over the entire surface

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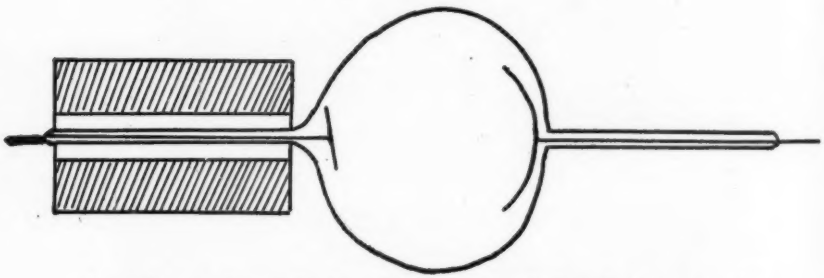

of anode or the cathode. The cores of the electromagnets were hollow in order to allow of the approach of the coil of the electromagnet to the terminals of the bulb, the glass seals of these terminals thus projecting into the hollow iron cores; only a circular area, therefore, on the cathode or anode forms the effective magnetic field. It seems probable that the best results would be obtained by enclosing the iron core entirely inside the bulb, platinizing the end of the iron core forming the anode, placing the aluminum mirror forming the cathode directly in the end of an iron core and nickel plating both iron cores to prevent the constant escape of gases from such large surfaces of iron. I had a bulb of this general description constructed, but found it impossible to exhaust it to the X-ray stage on account of the escape of gases from the iron; the iron was not nickel plated, however. The bulb was exhausted while it was strongly heated in an oven.

Fig. 5 is a photograph of the discharge in the X-ray bulb somewhat before the X-ray stage; a dark space surrounds the cathode.

Fig. 6 is a photograph of the same tube when the magnetic field is applied to the anode. This cone of rays is

solid until just before the X-ray stage; then it becomes hollow; and at the X-ray stage it appears only at the instant the

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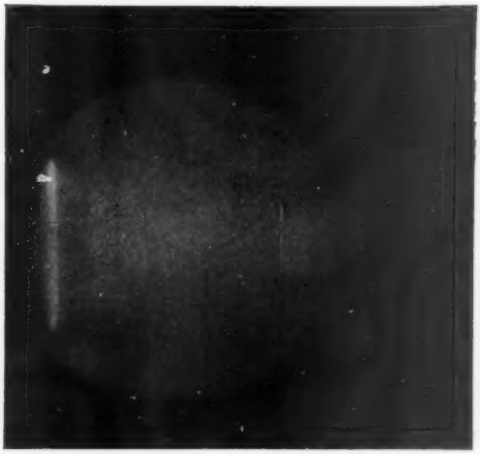

magnetic field is excited as a violet light, and then becomes indistinguishable in the fluorescence of the bulb. A violet brush, however, persists on the surface of the anode at the X-ray stage. When the vacuum was increased to so high a degree that the bulb could not be excited by a coil giving a six-inch spark, the application of the magnetic field immediately resulted in the production of the rays.

When the cathode mirror of an ordinary X-ray bulb is made the anode instead of the cathode, the current passing in the usually unfavorable way for the production of the rays, and at the same time is also the pole of a powerful electromagnet, the bulb gives out X-rays in great abundance. This is not the case when the magnet is not excited. The magnetic field, therefore, causes the anode to produce X-rays, probably by an increased energy of bombardment of the platinum focal plane by the positive ions.

Fig. 7 is a photograph of the X-ray bulb when the cathode mirror has been made the magnetic pole. Without the excitement of the magnetic field the bulb could not be made to give the X-rays even with a coil producing a six-inch spark; the vacuum having increased greatly during the previous use of the bulb.

When the field was excited, however, a brilliant fluorescence was produced, without any appearance of X-rays. The

negative ions, apparently, did not reach the anticathode, but instead formed fluorescent rings around the cathode. The cathode is thus made part of a hollow hemisphere of, in this case, orange light; when, however, the bulb was excited by a coil giving a twenty-inch spark with Leyden jars the bulb gave very brilliant X-rays at the moment of exciting

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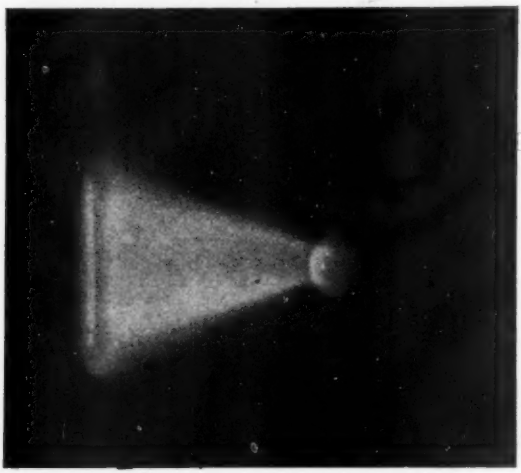

the magnetic field; in the case of the use of the six-inch spark coil, there were no Leyden jars in the circuit.

Besides the scientific side of the manifestations of the effect of the magnetic field on discharges in high vacua, there seems to be a practical use of the electromagnetic field in connection with the regulation of the discharge in X-ray bulbs. At present, when the vacuum has risen so high that the bulb cannot be excited, one is forced to apply heat to various regulators in order to drive out gases to increase the conduction. All regulators hitherto used are uncertain and dangerous to the life of the bulb in their application. I believe that a magnetic regulator applied to the anode would be of great service in hospital plants where a suitable electrical equipment can be had. The magnetic regulator is entirely safe and is constant in its action. It also enables one to pass readily from the production of hard rays to that of soft rays by the modification of the strength of the magnetic field; a modification difficult to accomplish without the application of the magnetic field.

The results are as follows:

1. When the anode in an X-ray bulb is also the end of a powerful electromagnet the application of the magnetic field results in the production of X-rays from a bulb which cannot be excited without the application of heat.

2. When the cathode forms the magnetic pole a violet

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brush-like light appears on the cathode, on the side away from the electromagnet; while the fluorescent light is forced somewhat beyond the cathode.

3. The use of Leyden jars in the case of low potential coils greatly modifies the effect of the application of the magnetic field, while with coils giving sparks over 20 cm. with comparatively large Leyden jars in circuit the application of the magnetic field to either anode or cathode results in greatly increased production of X-rays.

4. The application of a strong magnetic field at the anode with lines of force along the line of electric discharge forms a safe and useful method of regulation of X-ray bulbs.

5. An electrometer connected to the terminals of the exhausted tube shows a diminution of the apparent resistance of the tube when the anode is made the magnetic pole; and a rise in resistance when the cathode constitutes this pole. With Leyden jars in circuit the magnetic pole separates the oscillations, and rectifies the discharge to a certain extent.

Art. XIII.—*On the Glaciation of Orford and Sutton Mountains, Quebec;* by Alfred W. G. Wilson.

In a report published some years ago Dr. Chalmers,* the Pleistocene geologist of the Canadian Geological Survey, places the upward limit of glaciation in the Eastern Townships of Quebec at 1800 feet above sea level. In a paper read a few months later at the Boston meeting of the American Association for the Advancement of Science, in 1898, Professor Hitchcock† drew attention to the fact that Orford mountain is striated from bottom to top and that the ice movement was in a southeasterly direction. Hitchcock however gives the height of Orford mountain as about 5000 feet. Principal Dresser,‡ a year later and working independently, drew attention to the presence of exotic materials and striæ on the summit of Orford mountain (2800 feet approx.) over 800 feet above the highest limit set by Chalmers. In a recent report to the State geologist of Vermont, Hitchcock§ restates his original observations and adds additional data. In a still later article, published in the Ottawa Naturalist for May 1905, Chalmers‖ not only reasserts his original position without indicating in any way that he has re-examined the area in the vicinity of Mount Orford, but attempts to question the accuracy and veracity of both the observers whose results do not agree with his own.

During the past few years the writer has been collecting data for a study of the physiography of the St. Lawrence Plain and the adjacent areas. In carrying out these investigations it has been found necessary to review in the field practically all the work that had been done previously. New and it is believed more accurate determinations of the heights of all the prominent elevations on the St. Lawrence Plain have been made and independent studies of the Pleistocene geology of the district are under way.

While the physiographic studies are not sufficiently advanced to permit of immediate publication, the time seems opportune to offer the results of independent investigations which bear directly on the problem of the glaciation of Mount Orford and the adjacent peaks and ridges. Three new elevations are given which are based on barometric determinations that are

* Chalmers, Annual Report of the Geological Survey of Canada, vol. x, Part J, 1897.

† Hitchcock, Proceedings Amer. Asso. Adv. Sci., Boston, vol. 47, p. 292. 1898.

‡ Dresser, Canadian Record of Science, vol. viii, pp. 223–225, 1900–1902.

§ Hitchcock, Report of the Vermont State Geologist, p. 72, 1903–1904.

‖ Chalmers, Ottawa Naturalist, vol xix, pp. 52–55, 1905.

thought to be more accurate than the majority of the earlier observations. The method employed was as follows: An observer is stationed with one or two barometers at a point whose elevation is known from a railway profile. This observer takes readings during the working day at half-hour intervals and the data obtained are used to plot a time-pressure curve. In the field, barometers which were compared with the base barometers, both at the beginning and at the end of the day, were employed. The time of observation and the temperature were noted in each case when the field readings were taken. In cases where more accurate results were desired the field barometers were kept at the field stations for several hours and were read at half-hour intervals simultaneously with the readings of the base barometers. The elevations were later determined by reducing the readings obtained, corrections being applied for atmospheric temperatures. In this way a series of sixteen pairs of observations were taken and the six most closely accordant sets of readings were used in finding the height of Mount Orford as given here. In a series of over one thousand readings made by this method during the past two years, the writer has obtained some very satisfactory results where checks were afterwards obtained from railway profiles to determine the probable accuracy of the method employed.

General Character of the Topography of the District.

The eastern margin of the plain of the St. Lawrence is formed by the edge of a belt of crystalline and igneous rocks, the northward extension of the Green mountain range into Canada. The general trend of the structural lines of this belt of rocks is about 20 degrees to the east of north and we find that the trends of the main ridges and valleys in the vicinity of Orford and Sutton mountains are in conformity with the trends of the structural lines. The Sutton ridge, of which Sutton Mountain is the most important peak, consists of a central mass of gneiss flanked by quartzites and schists. It is the western of the two ridges which occur in this locality. Orford Mountain is the culminating peak of the Orford ridge, a topographic feature which extends into Canada from south of the Vermont boundary and lies immediately to the east of the Sutton ridge.

The central core of the Orford ridge is a diabasic rock and it is flanked by schists and serpentines. Between Orford mountain and the International boundry several minor peaks are developed on the ridge, occurring in the order named—Hog's Back, Sugar Loaf, Owl's Head, and Bear Mountain, the

latter lying in part to the south of the boundary. Three miles west of Bear Mountain a similar ridge known as Hawk Mountain is a prominent topographic feature.

West of the Sutton ridge, near the boundary, St. Armand Pinnacle is the culminating peak of a minor ridge of metamor-

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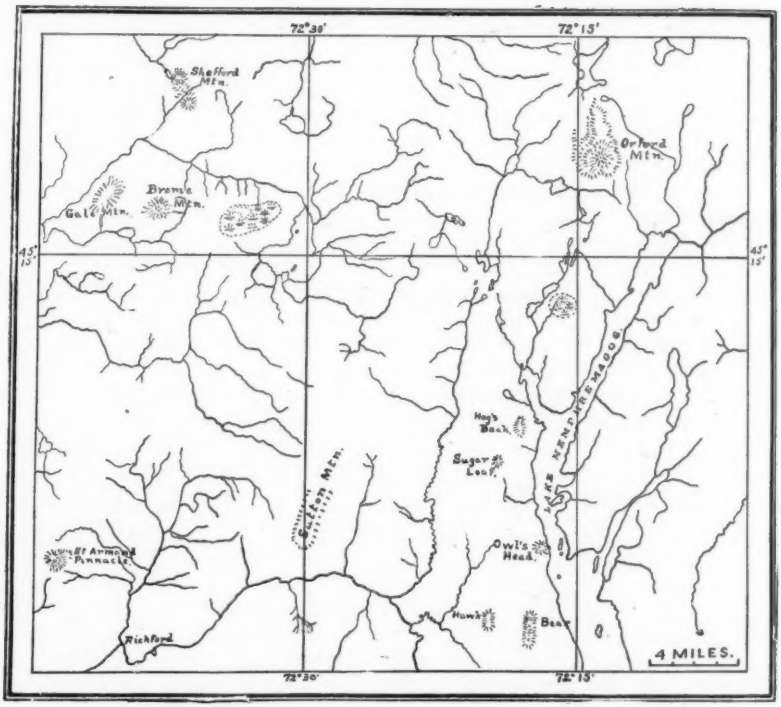

Sketch plan of the area west of Lake Memphremagog, Quebec.

phic rocks which has a greater development south of the boundary.

The valley between Sutton ridge and Orford ridge is cut on softer schists and serpentines. It is drained by the east branch of the Missisquoi River. This branch crosses Sutton ridge in a deep gorge (two miles south of the boundary line), through which the Canadian Pacific Railway runs, and joins the north branch of the same stream at Richford, Vt. The valley west of the Sutton ridge, between it and St. Armand ridge, is drained by the north branch of the Missisquoi River.

East of Orford ridge the lowest portion of a broad valley is occupied by Lake Memphremagog, a long narrow lake which receives a considerable amount of drainage from south of the boundary. The waters of Lake Memphremagog pass out northeastward by the Magog River—a tributary of the St. Francis—and eventually reach the St. Lawrence River. On the Orford ridge Mount Orford has an elevation of 2820 feet; Owl's Head, 2465 feet; Hog's Back, Sugar Loaf, and Bear Mountains are considerably lower. The lowest parts of the transverse depressions on either side of Owl's Head stand at elevations of about 1250 feet above sea level. Sutton Mountain rises to 3120 feet, and the depression to the south through which the Canadian Pacific railway runs has an elevation of about 500 feet near Mansonville station. The Missisquoi River at Richford, Vt. stands at 443 feet. St. Armand Pinnacle has an elevation of over 2500 feet (Dresser). The surface of Lake Memphremagog stands at 682 feet (Feb. 3, 1892) above sea level.

Character of the Surface of the Area.

In the valleys the surface of the bed rock is usually buried under a cover consisting of both modified and unmodified drift. In a number of localities small outcrops showing striated surfaces are known. The directions of the striations indicate that the general direction of the ice movement in the valley was controlled by the structural trends of the valley sides.

On the higher ridges even to the very summits a cover of drift materials, more or less mingled with recent debris from local sources, is found. The rock exposures are usually more numerous than in the valleys, and the striated surfaces indicate that the general direction of ice movement has been in a direction lying about thirty degrees to the east of south.

Special Localities.

Orford Mountain.—The Orford ridge reaches its highest elevation about twenty miles north of the International boundary in the mass usually called Orford Mountain. The highest point of the mountain is located on a rounded dome-like prominence near the southern end of the local ridge that constitutes the mountain. The summit of the dome is marked by a small nearly level area a little less than a quarter of an acre in extent. In detail this summit plain consists of low ridges of trap with rounded contours, the general trend of these local ridges being about S. 35° E. The hollows between these small ridges are filled with loose debris which contains a few fragments of the bed rock, but the greater portion of which consists of material foreign to the mountain. The small bare

rounded rock ridge which constitutes the very summit of the mountain rises about two feet above the surface of the soil cover which lies in the adjacent hollow to the east of it. On the south side of the summit area one of the rounded ridges still shows small rounded hollows on its surface which are the markings Dresser referred to when he wrote of the occurrence of glacial striations on the summit of the mountain. The

2

FIGURE 2. Summit of Orford Mountain, a small rounded dome with glacial scorings.

writer has examined these markings carefully, but could find no evidence to show that these furrows were produced by weathering processes acting on joint planes, as suggested by Chalmers.* Indeed, of all the loose material occurring at the summit, only a very small percentage can be attributed to the local disintegration of the rock in situ. The depth to which the decomposition due to weathering has visibly penetrated the exposed rock surfaces is very slight, except along fracture planes. Microscopically all of the primary minerals are found to be much altered for a considerable depth, but the rock is not disintegrated. The distribution of the effects of weathering is found to be fairly uniform, specimens from the base having practically the same appearance as those from the summit. On the west side of the summit dome, a few feet from the

* Ottawa Naturalist, vol. xix, p. 53.

locality where the striations were noted, is a furrow about three feet in depth and of slightly greater breadth, partly filled with loose debris at its southeast end. The form and shape of the hollow suggest that a joint block was removed by the ice and that the cavity was afterwards somewhat rounded out by the corrasive action of the ice sheet.

The soil at the summit consists in part of a sandy material containing many small chips and fragments of loose rock. The writer made a collection of rounded, subangular, and angular fragments derived from 12 different kinds of rock, all of which were foreign to the summit of the mountain. Among the fragments are pieces of schist from near the base, and a number of small pieces of pink granite, gneisses of several types, and vein quartz. Hitchcock also has recorded the finding of a fifteen-pound bowlder of gneiss in the same locality. The latter fragments are all unquestionably derived from the rocks to the north of the St. Lawrence river. The greater portion of the soil at the summit consists of a slightly arenaceous fine-textured grey clay which assumes a greyish-white color on drying. A qualitative chemical and a microscopic examination showed the presence of very small amounts of iron salts and of carbonates. Quartz sand is present in considerable amount, approximately 8 per cent, and the balance consists chiefly of kaolin, with a small percentage of mica, probably sericite.

A soil derived from the disintegration of the diabase of which the summit of the mountain is composed would be expected to contain much larger amounts of carbonates, would show a very much larger percentage of iron salts, and would normally be free from quartz. It is recognized that by the process of leaching the excess of the carbonates and of the iron salts might be removed in some cases, and that the quartz might be formed by the decomposition of the silicates. In this locality the soil is fine-textured close to the bed rock and it is not found to gradually grade downward into the underlying undecayed rock. It is also to be noted that this soil occurs less than three feet vertically below and horizontally, within a very few feet of the highest point of the mountain, and therefore it is not in a position favorable for the leaching action of soil waters. On the other hand, not only is the soil similar to that which is normally produced by the disintegration of the Archean rocks to the north, but also when its character is considered in conjunction with the other features already described, the cumulative evidence is such as to lead one to the conclusion that this soil also is of exotic origin. Since it is found to contain only a very small percentage of carbonates, one would infer that the limestones in the plain to the north

between the mountain and the main Archean areas had contributed but a very small percentage of the material of this soil.

On the slopes of the mountain, between the summit and the 2000 foot contour, erratics are fairly plentiful. The soil in which the trees and bushes on the slopes of the mountain are growing is similar to that at the summit and consists almost wholly of glacial till.

In conclusion it may be said that not only on the slopes adjacent to the summit but at the very summit of the mountain

3

FIGURE 3. Profile view of Owl's Head looking towards the northeast, showing the stoss and lee sides of the ridge.

itself are found practically all those data which are usually accepted by glacialists as evidence of ice transgression—till containing a large percentage of foreign material, erratics, and rounded and striated surfaces preserved on comparatively little decayed rock.

Other minor summits.—The Hog's Back and the Sugar Loaf mountains stand at a much lower level than Orford and were not specifically examined.

On Owl's Head at the summit rounded contours were observed on the northern and northwestern slopes, with a steep cliff face, presumably due to the plucking action of the ice, on the southeast [figure 4]. No striae were observed at the summit although the surface is well rounded, the curvature

being of the type that one would normally refer to the action of glacial ice even in the absence of striations, which would not be preserved on a rock surface where there was no protecting soil cap. In cracks and crevices at the summit there is an abundance of a sandy clay very similar to that found on Orford mountain. This soil contains numerous chips, many of which are of local origin. The summit rock is nearly bare except for the small amount of this soil found in the crevices and no large erratics were noticed. About twenty feet below

4

FIGURE 4. View showing the cliff face on the southeast side of the summit of Owl's Head.

the summit two pieces of vein quartz were picked up. On the slopes above the 2000 foot contour several small erratics were found in the soil cover, which consists largely of till.

Sutton Mountain.—The summit of Sutton Mountain, the highest ridge of the district, is heavily forested, and the surface of the ground is nearly all concealed beneath a moss carpet. Here and there the tops of minor ridges which cross the summit of the main ridge obliquely toward the southeast show rock outcrops. The soil appears to be much the same as on the other ridges of the district. At the summit the writer did not find any erratics, but this cannot be taken as conclusive that they do not occur within a few feet of it since they might easily be concealed by the vegetable growth of the area. A

number of erratics were found between 300 and 500 feet below the top. These included several pieces of a coarse grit which was probably derived from a basal member of the Potsdam formation, fragments of schists from the valley to the northwest, and a fragment of a coarse pegmatitic granite. At 300 feet below the summit a large bowlder of Laurdalite from Brome Mountain, 14 miles to the northwest, was found. Several similar pieces were picked up below this contour.

The most interesting feature of Sutton Mountain, however, is the occurrence of a series of remarkably well developed V-shaped notches which cross the summit of the main ridge in

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FIGURE 5. Summit of Sutton Mountain. A V-notch ten feet in depth with smooth sides, cut in gneiss, looking northwest.

a direction about S. 25 E. The sides of these small notches are planed off very smoothly, the west sides being the smoother of the two, in each case examined. The depth of these notches varies from four to about ten feet. The west side of one had a dip of 50° and the east side of the same notch was only a little less steep. This notch, whose form may be taken as typical of the form of all of them, was about ten feet deep and the ridges between it and the adjacent notches on either side had sharp crests as well defined as the ridge of the roof of a house. On the striated sides of these notches the large quartz masses in the gneiss were found planed off even with the rest of the surface. In all, twelve of these remarkable gullies were

noted and it is possible that others also occur along the crest of the mountain. They seem to owe their origin primarily to a system of joint fractures which loosened the blocks that once occupied the hollows. The smooth, even, striated sides are to be attributed to ice scouring.

Many of these small gullies cross the summit of the ridge and open out on each side over very steep cliffs. They constitute, in fact, very perfectly developed hanging valleys, but of a most unusual type in those instances where the hollow goes completely across the summit ridge.

St. Armand Pinnacle.—At St. Armand Pinnacle, on the lower slopes of the mountain, the writer has observed smoothed and striated surfaces on the bed rock. At the summit Mr. Dresser has noted similar striae trending to the east of south. A profile view of the peak from the west shows a gently ascending slope on the north side and a well developed cliffed face to the south—the latter presumably a plucked face.

Summary and Conclusions.

In conclusion it may be stated that not only in the depressions in this area, but also on all the important summits of the district, distinct and unmistakeable evidence of glacial transgression have been found. The cumulative character of this evidence has already been referred to, and one seems justified in concluding, with Mr. Dresser and Professor Hitchcock, that the height to which the ice sheet reached in this portion of eastern Canada is as yet an undetermined quantity.

Department of Geology, McGill University, Montreal.

ART. XIV.—*On the Drawing of Crystals from Stereographic and Gnomonic Projections;* by S. L. PENFIELD.

IN a previous communication by the present writer,* some methods for drawing crystal forms from a stereographic projection were described, and, after the publication of the paper, there was observed in a recent volume by Professor C. Viola of Rome,† a method, based upon different principles, which is so simple and ingenious that it seems wise to give a brief description of it, for the benefit of those readers of this journal who may be interested in the subject: this paper may also serve as a supplement to the writer's earlier article, referred to above.

In explaining the method, a general example has been chosen; the construction of a drawing of a crystal of axinite, of the tricilinic system. Figure 1 represents a stereographic projection of the ordinary forms of axinite, m (110), a (100), M ($1\bar{1}0$), p (111), r ($1\bar{1}1$), and s (201). As shown by the figure, the *first meridian*, locating the position of 010, has been chosen at 20° from the horizontal direction SS': This is wholly arbitrary, but it makes a good starting point for the construction of a stereographic projection.

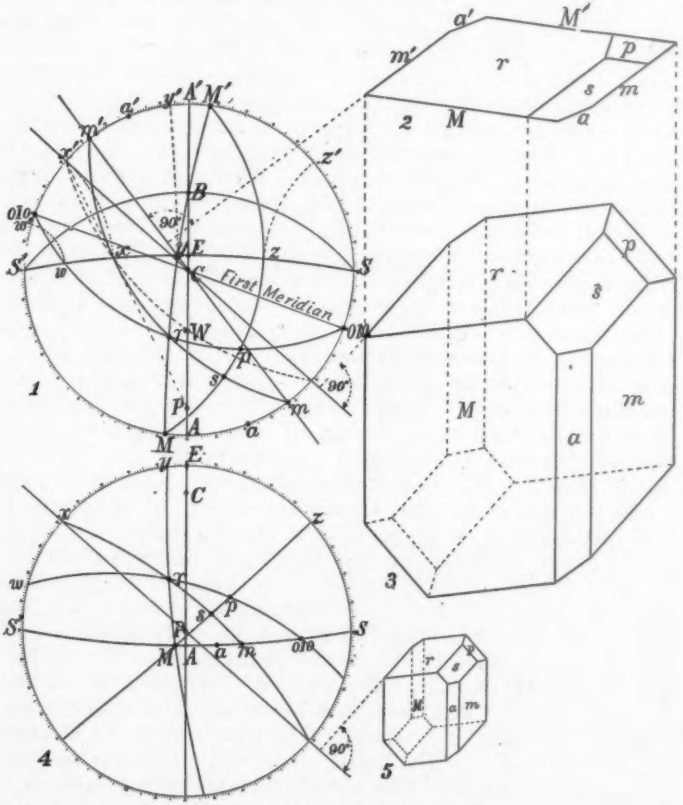
Figure 2 is a *plan*, or an orthographic projection of an axinite crystal, as it appears when looked at in the direction of the vertical axis. It may be derived from the stereographic projection in a simple manner, as follows:—The direction of the parallel edges made by the intersections of the faces in the zone m, s, r, m', figure 1, is parallel to a tangent at either m or m', and this direction may be had most easily by laying a straight edge from m to m' and, by means of a 90° triangle, transposing the direction to figure 2, as shown by the construction.

The construction of figure 3, which is called by Viola a *parallel-perspective* view, may next be explained: It is not a clinographic projection like the usual crystal drawings from axes, but an orthographic projection, made on a plane intersecting the sphere, represented by the stereographic projection, figure 1, along the great circle SES'; the distance EC being 10°. The plane on which a drawing is to be made may, of course, have any desired inclination or position, but by making the distance CE equal 10° and taking the first meridian at 20° from S, almost the same effects of plan and parallel-perspective are produced as in the conventional method of drawing from axes, where the eye is raised 9° 28′ and the crystal turned

* This Journal (4), xix, p. 39, 1905.

† Grundzüge der Krystallographie, p. 29, W. Engelmann, Leipzig, 1904.

18° 26′*; in fact, even when drawn on quite a large scale, the plan and parallel-perspective views, figures 2 and 3, are so nearly identical with corresponding figures of axinite, page 73 of the writer's earlier paper just referred to, that the eye can



FIGURES 1 to 5. Development of a plan and parallel-perspective figure of axinite, triclinic system, from a stereographic projection.

scarcely detect any difference between them, even when placed one above the other.

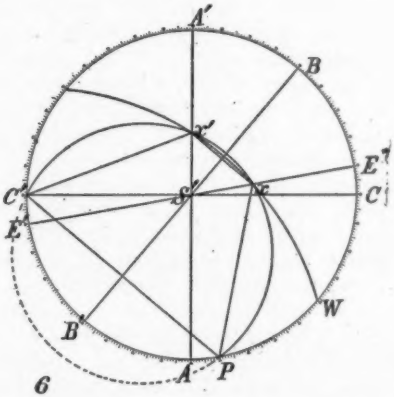
The easiest way to explain the construction of figure 3 from figure 1 is to imagine the sphere, represented by the stereographic projection, as revolved 80° about an axis joining *S* and *S′*, or until the great circle *SES′* becomes horizontal. After such a revolution, the stereographic projection shown

* This Journal (4), xix, p. 40, 1905.

in figure 1 would appear as in figure 4, and the parallel-perspective drawing, figure 5, could then be derived from figure 4 in exactly the same manner as figure 2 was derived from figure 1. This is, for example, because the great circle through m, s and r, figure 4, intersects the graduated circle at x, where the pole of a vertical plane in the same zone would fall, provided one (artificially constructed or otherwise) were present; hence the intersection of such a surface with the horizontal plane, and, consequently, the direction of the edges of the zone, would be parallel to a tangent at x: In other words, figure 5 is a *plan* of a crystal in the position represented by the stereographic projection, figure 4. Although not a difficult matter to transpose the poles of a stereographic projection so as to derive figure 4 from figure 1, it takes both time and skill to do the work with accuracy, and it is not at all necessary to go through the operation. To find the direction of the edges of any zone in figure 3, for example m s r, note first in figure 1 the point x, where the great circles m s r and SES' cross. During the supposed revolution of 80° about the axis SS', the pole x follows the arc of a small circle and falls finally at x' (the same position as x of figure 4) and a line at right angles to a diameter through x', as shown by the construction, is the desired direction for figure 3. Similarly for the zones pr, MrM' and $MspM'$, their intersections with SES' at w, y and z are transposed by the revolution of 80° to w', y' and z'. The transposition of the poles w, x, y and z, figure 1, to w', x', y' and z' may easily be accomplished in the following ways:—(1) By means of the transparent, small-circle protractor described by the writer,* the distances of w, x, y and z from either S or S' may be determined and the corresponding number of degrees counted off on the graduated circle. (2) Find first the pole P of the great circle SES', where P is 90° from E or 80° from C, and is located by means of a stereographic scale or protractor: A straight line drawn through P and x will so intersect the graduated circle at x', that $S'x$ and $S'x'$ are equal in degrees. The reason for this is not easily comprehended from figure 1, but if it is imagined that the projection is revolved 90° about an axis AA' so as to bring S' at the center, the important poles and great circles to be considered will appear as in figure 6, where P and C' are the poles, respectively, of the great circles $ES'E'$ and $AS'A'$, and x is $41\frac{1}{4}$° from S' as in figure 1. It is evident from the symmetry of figure 6 that a plane surface touching at C', P and x will so intersect the great circle $AS'A'$ that the distances $S'x$ and $S'x'$ are equal. Now a plane passing through C', P, x and x', if extended, would intersect the sphere as a

* This Journal (4), xi, p. 17, plate I, 1901.

small circle, shown in the figure, but since this circle passes through C', which in figure 1 is the pole of the stereographic projection (antipodal to C), it follows that it will be projected in figure 1 as a straight line, drawn through P and x.* (3) In figure 6, B is located midway between E and A', $BS'B'$ is a great circle, and W, 40° from C, is its pole: It is now evident from the symmetry of the figure that a great circle through W and x so intersects the great circle $AS'A'$, that the



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distances $S'x$ and $S'x'$ are equal. Transferring the foregoing relations to figure 1, W, 40° from C, is the pole of the great circle SBS', and a great circle drawn through W and x falls at x'. However, it is not necessary to draw the great circle through W and x to locate the point x' on the graduated circle: By centering the great circle protractor, described by the writer,† at C, and turning it so that W and x fall on the same great circle, the point x may be transposed to x', and other points, w', y' and z', would be found in like manner.

The three foregoing methods of transposing x to x', z to z', etc., are about equally simple, and it may be pointed out that, supplied with transparent stereographic protractors, and having the poles of a crystal plotted in stereographic projection, it is only necessary to draw the great circle SES' and to locate one point, either W or P, in order to find the directions needed for a parallel-perspective drawing, corresponding to figure 3. Thus, with only a great circle protractor, the great circle through the poles of any zone may be traced, and its intersection with SES' noted and spaced off with dividers

* This Journal (4), xiii, pp. 247–249 and 269–271, 1902.
† Ibid. (4), xi, pp. 21–22, 1901.

from either S or S'; then the great circle through the intersection just found and W is determined, and where it falls on the divided circle noted, when the desired direction may be had by means of a straight edge and 90° triangle, as already explained.

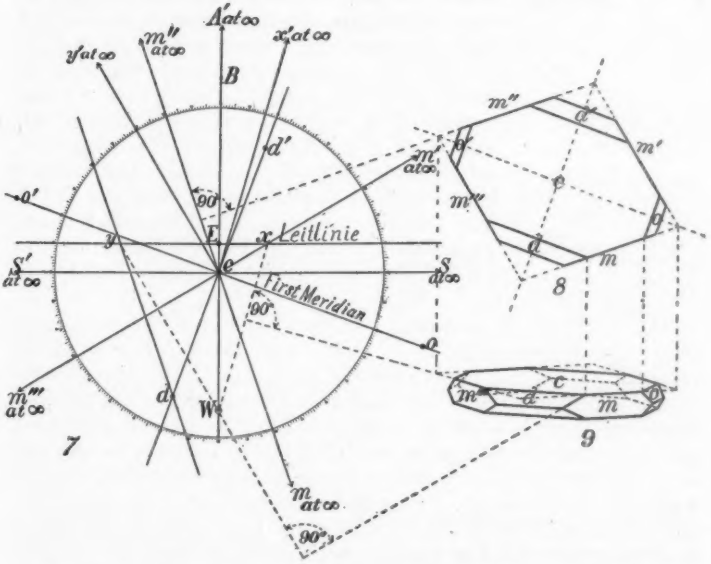
The gnomonic projection is preferred by many for representing crystallographic relations, and it seems best, therefore, to indicate how readily the methods just explained may be adapted to this kind of projection. This subject has received careful treatment from Goldschmidt * and G. F. H. Smith, † hence what follows might seem somewhat superfluous; but although the final results of the crystal drawings are essentially the same as those of the authors just mentioned, the presentation and explanations here given are somewhat different, and it is hoped that some of the suggestions may be of service to students of crystallography.

As an illustration, the method of drawing a simple combination of barite has been chosen. The forms shown in figures 7, 8 and 9 are c (001), m (110), o (011) and d (102). The location of the poles in the gnomonic projection is shown in figure 7, where, as in figure 1, the *first meridian* is taken at 20° from the horizontal direction SS'. A simple method for locating the poles o and d on their respective meridians is by means of the stereographic scale No. 3, described by the writer,‡ by laying off with this scale double the angle $c \wedge o$ and $c \wedge d$; for both stereographic and gnomonic scales are derived from a table of natural tangents, 2° of the former being equal to 1° of the latter. The poles of the prism m and the locations of S and S' (compare figure 1) fall in the gnomonic projection at infinity. In any plan, such as figure 8, the direction of an edge made by the meeting of two faces is at right angles to a line joining the poles of the faces, shown in figures 7 and 8 by the direction at 90° to the line joining m'' and c.

The parallel-perspective view, figure 9, is an orthographic projection (compare figures 1 and 3) drawn on a plane passing through S and S', and intersecting the sphere on which the gnomonic projection is based as a great circle,§ passing through E, figure 7, and drawn parallel to SS', the distance cE being 10°: This great circle is called by Goldschmidt the *Leitlinie*. To find such intersections as between m''' and c, and m and d, figure 9, note, as in figure 1, where the great circles through the poles of the faces intersect the *Leitlinie;* thus, the one

* Zeitschr. Kryst., xix, p. 352, 1891.
† Min. Mag., xiii, p. 309, 1903.
‡ This Journal (4), xi, p. 7, 1901.
§ All great circles in the gnomonic projection are represented by straight lines.

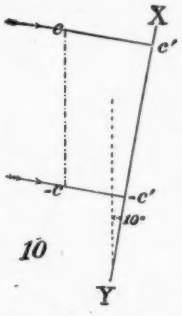
through m''' and c at x, and that through m and d (through d parallel to $m\ m''$, since m and m'' are at infinity) at y. Next imagine the points x and y transposed as in figure 1 to x' and y', which latter points, however, are located at infinity: This transposition is done by locating first the so-called *Winkelpunkt*, W, of Goldschmidt, 40° from c in figure 7, and as in figure 1, 90° from a point B, which is an equal number of



FIGURES 7 to 9. Development of a plan and parallel-perspective figure of barite, orthorhombic system, from a gnomonic projection.

degrees from E and A' (compare figure 6). Of the three methods given on pages 208 and 209 for transposing x and y to x' and y', the third may be easily applied in the gnomonic projection. Great circles, or straight lines, through W and x and W and y, figure 7, if continued to infinity, would determine x' and y', which is accomplished by drawing lines parallel to Wx and Wy through the center. It is not necessary, however, to draw the lines Wx and Wy, nor the parallel lines through the center; all that is needed to find the directions of the edges $m''' \wedge c$ and $m \wedge d$ is to lay a straight edge from W to x, respectively W to y, and with a 90° triangle transpose the directions to figure 9, as indicated in the drawings. The principles are exactly the same as worked out for the interrelations of figures 1 and 3. As in the case of the stereographic projection, it is

evident that, given the poles of a crystal plotted in the gnomonic projection, it would be necessary to draw only one line, the *Leitlinie*, and to locate one point, the *Winkelpunkt*, *W*, in order to find all possible directions for a plan and parallel-perspective views, corresponding to figures 8 and 9.



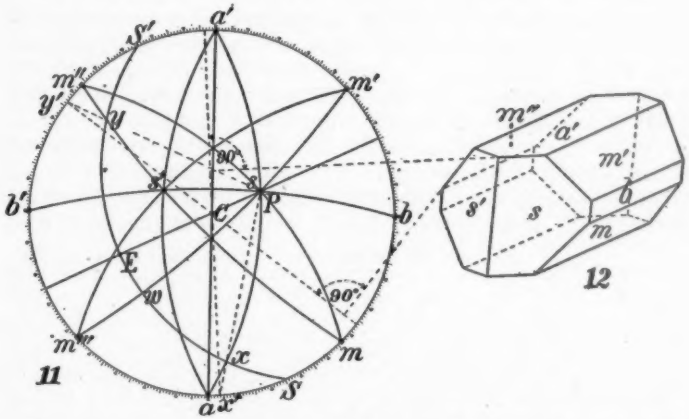
In any parallel-perspective drawing corresponding to figures 3 and 9, it is important to keep in mind that, since the projection is orthographic and made on an inclined surface, there will be some fore-shortening of vertical lengths. Thus, if one has in mind a certain height of a crystal, or the length of a vertical axis $c,-c$, figure 10, and if XY is the trace of the plane on which the projection is made, the length $c,-c$ would become fore-shortened to $c',-c'$.* The fore-shortening is best done graphically, or it would be the length $c,-c$ times the sine of 10°, provided *E*, as in figures 1 and 7, is 10° from the center.

The methods of drawing, as developed in the foregoing pages, have been such as to yield parallel-perspective figures essentially like the conventional ones found in treatises on crystallography and mineralogy; but, as already stated, the plane on which a drawing is to be made may have any desired position, and it may not be out of place to indicate briefly, by an example, how easily the methods may be modified to suit varying requirements. Figure 11 represents a stereographic projection of augite, the forms being *a*, *b*, *m* and *s* ($\bar{1}11$), and it is desired to draw a parallel-perspective on a plane parallel to the pyramid face *s*, $\bar{1}11$. Through *s* draw a diameter, and on it locate *E*, 90° from *s*; then draw the great circle *SES'*: Under the conditions, the pole corresponding to *P* of figure 1 is *s* in figure 11. In the parallel-perspective, figure 12, such directions as the edges $a' \wedge s$ and $m'' \wedge s'$ are found by noting in figure 11 where the great circles $a'\,s$ and $m''\,s'$ cross *SES'* (at *x* and *y*) and then following out the construction indicated by the figure, as previously explained.

In figure 12, the plane angles of *s* are the same as those of an actual crystal, and the angles, or their supplements, may always be measured on the great circle *SES'* of the stereographic projection. To measure the angle made by the edges $a's$ and $m's$, figure 12, the great circles through the poles, figure 11, are at right angles, respectively, to the two edges, and their intersections with *SES'* are at *x* and *w*, hence the angular distance *x* to *w*, measured with a stereographic protractor as 47°, is the supplement of the desired angle, or 133°.

* Compare figure 5, page 41; this Journal (4), xix, 1905.

Certainly the methods of getting both a plan and a parallel-perspective from either a stereographic or gnomonic projection appeal strongly to one at first, both because of their simplicity and the doing away with the multiplicity of construction lines which frequently are needed in drawing from axes. To convince himself of the relative advantages of the different methods of drawing crystals, the writer has taken special pains to experiment with those explained in this paper, and it is his belief that most persons, especially beginners, will find it easier to draw from axes, while at the same time finished



FIGURES 11 and 12. Development of a parallel-perspective of augite, drawn on a plane parallel to *s*, 111.

drawings will in most cases be completed more quickly and, probably, with greater accuracy. It certainly would seem as though with the axes constantly before one, they must be of value to a student in developing the symmetry of a crystal figure during the process of drawing. When it comes to a complicated problem, such as one in the triclinic system, it may be questioned whether it is easier to incline the axes and draw from them, or to make either a stereographic or gnomonic projection and draw from it: The determination of such a question would depend somewhat upon the data at hand, and largely upon one's familiarity or facility with either the one or the other method. Certainly, as is often the case, having made either a stereographic or gnomonic projection for the purpose of study, it would be easier to draw from the projection than to plot the inclined axes and draw from them. Every one who is at all interested in crystal drawing would do well to become familiar with the methods based on the use of

the stereographic and gnomonic projections, for they may be employed to advantage when drawing from axes becomes difficult or impossible. For example, in some twin crystals, when drawing from axes, serious difficulties are at times encountered in finding the intersections of interpenetrating surfaces; difficulties readily overcome, however, by drawing from the projections, if the poles of the twin crystal have been plotted; or again, the projections may be employed in drawing some odd shape or some obscure crystal, the planes of which cannot be referred to axes.

To any one desiring to make much use of the methods of drawing from either of the two projections, it is recommended to employ a T-square and, in connection with it, special triangles, figure 13, similar to those previously described by the writer*, as follows:—The drawing paper is fastened to a board so that a T-square gives the direction SS', figures 1 and 7. A 20°, 90° triangle, *I*, gives the direction of the first meridian of the two projections, and, in any plan, the direction of the front-to-back, or $a,-a$ axis, and, triclinic system excepted, the right-to-left, or $b,-b$ axis. A 90°, 25° 30′ triangle, *II*, is used

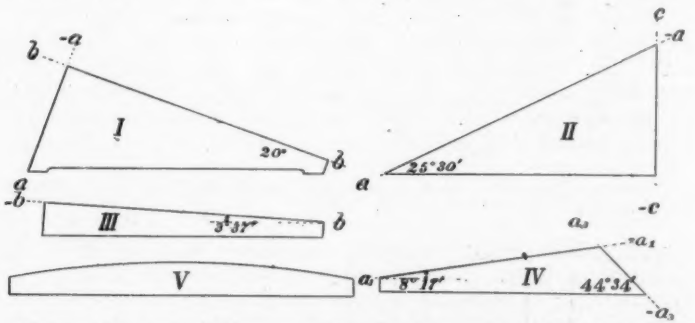


FIGURE 13. Special triangles to be used in connection with a T-square when drawing from the stereographic or gnomonic projections.

for uniting corresponding points of plan and parallel-perspective figures, parallel to the $c,-c$ axis, and it also gives the front-to-back or $a,-a$ axis in any parallel-perspective figure, when the axis is 90° to the vertical. A truncated 3° 37′ triangle, *III*, gives the direction of the right-to-left or $b,-b$ axis of parallel-perspective figures, provided the system is not triclinic. An 8° 17′, 44° 34′ triangle, *IV*, gives the directions of two of the horizontal axes in the hexagonal system, triangle *III* giving the third. Lastly, a circular arc, *V*, is used for

* This Journal (4), xix, p. 53, 1905.

drawing the great circle *SES'*, figure 1. The angles of the triangles, figure 13, are based upon the data chosen for constructing figures 1 and 7; namely, the first meridian 20° from *S*, and *E* 10° from the center of the projections: For any desired variation from these data the angles could be calculated readily. The writer has found triangles made from heavy bristol-board in every respect serviceable for pencil work, and if cut, for example, as shown in figure 13–*I*, so that only two extremities of the base line touch the T-square, they may first be made approximately right and then accurately adjusted by taking off a little from one end or the other by rubbing against sandpaper. Referring to figure 8; having determined the direction $c \wedge m'''$, and knowing the orthorhombic symmetry of the crystal, the remaining lines could all be determined by means of triangle *I*. From figure 8; and by use of the triangles *II* and *III*, figure 9 could be constructed by finding only one direction, for example, $d \wedge m$. The triangles thus serve as time-savers to any one engaged in this kind of crystal drawing, and likewise insure increased accuracy in the work.

Mineralogical Laboratory of the Sheffield Scientific School
of Yale University, New Haven, Conn., December, 1905.

ART. XV.—*A Suggested Cause of Changes of Level in the Earth's Crust;* by Rev. O. FISHER, M.A., F.G.S., Cambridge, England; Author of the "Physics of the Earth's Crust."

DR. SPENCER in America,* and Prof. Hull in England,† have for some years past been drawing the attention of geologists to the great changes in the relative levels of land and ocean on both sides of the Atlantic, evidenced by the drowned plains bordering the continents intersected by deep canyons, which are the now submerged continuations of existing river channels. These changes of relative levels amount frequently to a mile or more.

Great changes of level are among the rudiments of the grammar of Geology. But the recency of those described, viz. Pliocene or early Pleistocene times, is remarkable.

It rests with those who believe that the earth is solid to explain these phenomena on that hypothesis. But for those geologists who think that a liquid substratum of unknown depth underlies the cooled crust, the following explanation appears plausible.

It being granted that the earth is a cooling body, if the cooling takes place in a liquid which expands by heat it will do so by convection currents. Hence convection currents must exist in the substratum. The action of such currents has not yet been brought under the dominion of mathematical methods, but the general principle of their action appears to be as follows: Suppose a mass of liquid consisting of parallel layers increasing in temperature with the depth. It would be in unstable equilibrium, and that state could not continue; somewhere a column of the fluid would begin to ascend, and to flow away horizontally at the surface. The waste in the lower parts of the ascending column would be supplied by the inflow of the surrounding liquid, which would depress the isotherms in it, and the whole of the region affected would become cooler. But momentum will have been gained in the

* Reconstruction of the Antillean Continent, Bull. Geol. Soc. America, vol. v, p. 103, 1895. Great Changes of Level in Mexico, Bull. Geol. Soc. Amer. vol. ix, p. 13, 1898. Submarine Valleys off Amer. Coast and in the North Atlantic, Ib. vol. xiv, p. 207, 1903. The Submarine Great Cañon of the Hudson River, this Journal, vol. xix, p. 1, 1905. Physiographic Improbability of Land at the North Pole and Bibliography of Submarine Valleys of North Amer., Ib. p. 333, 1905. Reply to Mr. Huddleston, Geol. Mag., vol. xi, p. 559, 1899.

† Submerged Terraces and River Valleys bordering the British Isles, Trans. Victoria Institute 1897-8; also Geol. Mag., vol. x, p. 351, 1898. The Submerged Platform of Western Europe. Geol. Mag., p. 478, 1898. Suboceanic Physical Features, Geol. Mag., vol. vi, p. 132, 1899.

column and in the whole region affected, which will carry on the movement until any given level in it contains liquid cooler, and therefore more dense, than the average of the general mass at the same level. Gravity and friction will gradually arrest the motion, and, on account of the greater density, the liquid in the region affected will begin to descend. The cooling process will in the meanwhile be taken up by an ascending column elsewhere. If we had begun the cycle with a descending current, the reasoning and final result would have been similar.

The surface of the liquid above an ascending column will be somewhat elevated, and above a descending one depressed; thus the whole mass of liquid will experience the alternate elevation and depression of regions of its surface, and if there were a cooled crust floating upon it, in areas sufficiently wide to compensate for the rigidity, it would partake in the changes of level of the surface of the substratum.

If a limited coastal region were elevated the change of level would be local and merely confined to that region,—the effect on the actual sea level being small. But if the region of the sea bottom were depressed the level of the surface would be everywhere lowered, and the coastal regions all over the globe would apparently be raised; and vice versa. The phenomena seem to point to this depression or elevation of extensive regions of the sea bottom as being the cause of the simultaneous recession from or approach to the coasts of the sea margins.

There appears to me no possible way of accounting for the change of level indicated, unless upon the hypothesis of a liquid substratum beneath the cooled crust. I am pleased to notice that Dr. Nansen seems to approve of this theory. Accepting this view, we get the important consequence of isostacy which seems to have been confirmed by observations, and on that theory I have explained the anomalies of the deflection of the plumb line in India, in a paper which the Superintendent of the trigonometrical surveys has thought worthy of being printed as an appendix to a future report.

Thus we have a suggestion offered for the cause of the changes of level of the earth's surface, which appears worthy of consideration as a working hypothesis. If the substratum is liquid, this kind of movement must necessarily take place in it; but whether it would be quantitatively competent to produce the observed phenomena cannot easily be decided. That would apparently depend chiefly upon the depth of the liquid involved in the process.

The amount of the elevation or depression of the surface of the lithosphere, whether continental or suboceanic, would be approximately measureable from the sea surface. And if an area partly continental and partly oceanic were affected,

that is one including a coast line, the whole change of level would be indicated on the coast line, although there might be no change in the relative levels of the land and the sea bottom.

By a somewhat complicated mathematical investigation,* I believe that I have proved that if the continents contain extensive areas nearly at the sea level, as is the case at the present day, the substratum beneath these areas must be more dense than the average beneath the oceans; and that consequently descending currents may be expected to be now in progress beneath those low-land areas; and on the whole, ascending currents beneath the oceans, the suboceanic crust of which may be partly supported by the upward currents pressing against it; and in that case it would rise or fall in accordance with the play of the currents. The present general low level of the land areas may probably be exceptional, being the final and temporarily stationary stage of a period of depression. Unfortunately my mathematical method does not lend itself to the comparison of densities in the case of a land area raised above the sea level; but it seems reasonable to expect that in such a case there would be a reversal of the direction of the convection currents. Thus where land areas can be proved to have existed formerly, where the ocean now rolls, it seems probable that a change in the direction of the currents in the substratum from up to down may be the cause of their subsidence.

I would therefore hazard the suggestion that the apparent elevation or depression of the continents, which I gather from the recent papers mentioned probably takes place simultaneously over the whole globe, are caused by the fall or rise of areas of the sea bottom through the play of convection currents. I conclude that during the periods of land elevation there have been no extensive tracks of low land near sea level, but that entire continents have stood higher; as favored by Nansen and lately considered by Spencer;—unless this is the case, I do not think my suggestion will hold, because the assumption on which I prove the substratum in the ocean to be less dense than that of the land is, that the continental area is at present on the average not much raised above the sea level. If it were much raised I think the lesser density would not appear as the result of the calculation.

If instead of beneath the ocean an upward convection current were to occur beneath the continent, the change of level would be local and would affect the superincumbent area only. This would cause the kind of uplift which is found in plateau regions without much crumpling of the strata.

* Proceedings Cambridge Phil. Soc., xiii, Part II, p. 106, 1905.

The investigations of Dr. Spencer, Prof. Hull, and Dr. Nansen* have introduced to us the knowledge of much more recent great change of level than I think had previously been suspected. This circumstance seems to favor the explanation now suggested, because the cyclical changes in convection currents in the substratum beneath the crust might be expected to recur at frequent intervals.

Addendum to a Suggested Cause of Changes of Level in the Earth's Crust, Jan. 3, 1906.

Since forwarding the above I have received an important paper by Lieut.-Colonel Burrard, R.E., F.R.S., Superintendent of the Trigonometrical Surveys of India, "on the intensity and direction of the force of gravity in India,"† in which I meet with a statement that appears of much interest in connection with my suggestion about convection currents in the substratum of the earth's crust.

"Between 1865 and 1873 observations were taken at 31 stations in India by Captains Basevi and Heaviside, with the Royal Society's seconds pendulum." In 1903–4 renewed observations were taken by Major Lenox Conyngham with a half second pendulum. "His first station was Dehra Dun. His results there were astonishing, for they show that Basevi's value was no less than 0·103 centimeters too small." [Note] "This extraordinary difference could only mean that Basevi's final value of N [the number of vibrations in 24 hours] was too small by four whole seconds of time. Basevi's observations at Dehra Dun lasted five months, and included 234 independent swings, taken at pressures varying from half an inch to 28 inches, and at temperatures varying from 48° to 102° Fahr.

"The force of gravity as observed by

	Basevi and Heaviside 1865–73. cms.	Lenox Conyngham. 1904. cms.	Difference. cms.
Dehra Dun	978·962	979·065	+0·103
Madras	978·237	978·281	+0·044
Bombay	978·605	978·632	+0·027
Mupooner	978·751	978·795	+0·044 "

Colonel Burrard remarks that these differences are not affected by any constant quantity, and that, "Basevi's and Heaviside's observations were taken with a care that it is difficult for us to equal." "The only faults which have been

* Bathymetric Features of the North Polar Sea, with a Discussion of the Continental Shelves and previous Oscillations of the Shore Line (Christiana 1904).

† Phil. Trans. Royal Soc., Series A, vol. ccv, 1905.

found with their work are such as would tend to produce constant error." Is it not possible that the large difference in the force of gravity at Dehra Dun may be to some extent due to a *real* change of density beneath that station in the interval of between thirty and forty years? We know that during 1905 a severe earthquake was experienced at Dehra Dun; and the stress which caused it must have been accumulating since Basevi's time. May not that process have been accompanied by a gradual change of density which Conyngham's observations revealed in progress?

Taking the mean force of gravity to be 978 centimeters, a change of density amounting to $1\frac{1}{2}$ per cent in a depth of 50 miles in the underlying magma at Dehra Dun would have been quite sufficient to cause the whole of the observed difference in gravity, supposing the higher density of the two to be 3.

It seems, therefore, that if this change of gravity at Dehra Dun cannot be accounted for by errors of observation, it amounts to a proof that changes of density, and therefore movements, have taken place in the substratum of the earth's crust in sub-Himalayan regions within the last thirty years.

ART XVI.—*North American Plesiosaurs: Elasmosaurus, Cimoliasaurus, and Polycotylus;* by S. W. WILLISTON. (With Plates I–IV.)

DURING the past two years I have had the opportunity of studying nearly all the specimens of plesiosaurs preserved in the American museums, a study undertaken in the preparation of a monographic revision of the American forms, and, it is hoped, of the genera of the world also. The accumulation, however, of material recently has made the completion of the task a more arduous one than was at first suspected. I have therefore determined to publish from time to time the more important results obtained, with the hope eventually of gathering the whole together in a final monographic revision. Furthermore, I am convinced that specimens of this order of reptiles are not as rare in America as has been believed, and hope to continue field search until the more important characters of the group have been established. I have already said, and I repeat, that the taxonomy of the plesiosaurs is very perplexing; I doubt if that of any other order of reptiles is more so, chiefly because of the fragmentary nature of much of the known material.

I desire in this place to express my sincerest thanks to those gentlemen who have generously aided me by the communication of material under their charge, and in particular to Dr. Witmer Stone of the Philadelphia Academy of Sciences, Professor Henry F. Osborn of the American Museum of New York City, President Slocum and Professor Cragin of Colorado College, and to my old friend, Mr. William H. Reed, curator of paleontology of the University of Wyoming. I am especially grateful for the generosity with which Professor Charles Schuchert, the curator of the Geological Department of the Yale Museum, has placed freely at my disposal the rich collections of that museum, collections which I had, for the most part, assisted in making a good many years ago; and to which were added many useful notes made by the late Professors Marsh and Baur, and by myself while an assistant in that museum twenty years or more ago. Professor Marsh had begun, before his death, the critical study of the plesiosaur material of the Yale Museum, and had had much of it prepared and some illustrations made. All of this has been placed at my disposal. Professor Marsh had not definitely determined any of his species, and had only tentatively located some of them in genera, aside from the Jurassic species described by him as *Pantosaurus striatus*. Most of the observa-

tions of his notes have been anticipated by myself or others; others new to me I shall fully acknowledge in each case. The present paper will deal chiefly with this material, that especially belonging to the genus *Elasmosaurus*. Other material in the collection will be discussed in later papers, so far as the more important characters are concerned.

Cimoliasaurus.

The genus *Cimoliasaurus* has been, and yet is, poorly understood. Lydekker subordinated a dozen or more generic names as synonyms, some of which have been accepted as such by later writers. Professor Marsh was inclined, as his notes show, to accept the name *Cimoliasaurus* in lieu of *Elasmosaurus* for the species now in the Yale Museum. A brief review, therefore, of the real characters of that genus, as interpreted by the light of considerable material, will not be out of place here.

The type of the genus and species *Cimoliasaurus magnus* Leidy is a number of dorsal and cervical vertebræ from Monmouth county, New Jersey, probably from rocks of an epoch corresponding with the Fort Pierre Cretaceous, and they have been, for the most part, well figured by Leidy in his "Cretaceous Reptiles." With the original specimens he later associated a series of fourteen vertebræ, or rather centra of vertebræ, from the same locality, and he speaks of such bones being common in the deposits of New Jersey. Leidy, however, sadly misinterpreted the positions of his centra in the vertebral column, nor was Cope much more correct in his interpretation of them. I would interpret figures 13–15 of Plate V of the above-mentioned work as of a posterior cervical centrum; figure 16, a more posterior cervical or early pectoral; figures 17–19, a median or postero-median cervical. Figures 1–3 of Plate VI represent a dorsal centrum; figure 4 is of an anterior dorsal, as is also figure 5; figures 6 and 7 are of a posterior cervical; 8–15, of median cervicals; 16–19, of an anterior cervical.

Leidy's description of the genus *Discosaurus* appeared on the page following that of *Cimoliasaurus*, and was based upon two caudal vertebræ from the Cretaceous of New Jersey (Plate V, figures 1–3) and an anterior caudal vertebra from the same region. Other vertebræ from the Cretaceous of Mississippi (figures 10, 11) he afterwards separated as the type of a distinct species, and was probably correct in so doing. Cope long ago showed the similitude of these vertebræ to those of *Cimoliasaurus* and made the name *Discosaurus* a synonym, in which Leidy acquiesced.

We may therefore assume that all these vertebræ, save those from Mississippi, pertain not only to *Cimoliasaurus*, but to

the type species as well; from which certain definite generic characters are evident. Cope erred in most of the distinctive characters that he assigned to the genus *Elasmosaurus*, but was correct in an important one,—the length of the neck. We shall see that in all the known species assigned to *Elasmosaurus*, of which this part of the skeleton is known, the neck is very long, and that all of its vertebræ, save the most posterior ones, are longer than broad. *Cimoliasaurus* is, therefore, a relatively short-necked plesiosaur, though not so short as in the genus *Polycotylus*. Nothing is known of the pectoral girdle or of the skull of *Cimoliasaurus*, and more decisive characters may be,—I believe will be, forthcoming when these parts of the type species are known. Unfortunately, here as among the mosasaurids, it may be a long time before the subject is cleared up finally. I am, however, firmly of the opinion that the two genera are distinct, and therefore object to the indiscriminate use of *Cimoliasaurus* in the way that it has been used, both in this country and in Europe.

While we may assume the distinction between *Cimoliasaurus* and *Elasmosaurus*, we can by no means do so for the genus *Brimosaurus*, described long ago by Leidy from a dorsal vertebra from the Cretaceous, probably Benton, of Clark county, Arkansas. I believe that this genus will comprise species now located under *Elasmosaurus*, and possibly, if not probably, the type species of that genus. For the present, however, we do know pretty nearly what *Elasmosaurus* is, and I shall therefore use this name as the designation of at least ten species of the genus known to me, so far as they can be distinguished by true generic characters. I should perhaps except one of the species described below, *Elasmosaurus (?) marshii*, because I am of the opinion that it will eventually be necessary to locate it elsewhere. Indeed I should do this now, did I not feel doubtful of its relationships to some other, as yet poorly distinguished genera.

Elasmosaurus.

The type species of *Elasmosaurus* was founded by the late Professor Cope, and based upon a specimen ascribed to the Niobrara Cretaceous of western Kansas, in the vicinity of old Fort Wallace. From the locality given for the type specimen I long ago concluded that its horizon was really basal Fort Pierre Cretaceous, and not Niobrara; and an examination of the type specimen, now in the Academy of Natural Sciences of Philadelphia, to which much of the original matrix yet adheres, confirms this determination. Though the type specimen included a large part of the skeleton, yet through some

misinterpretation of its parts by Professor Cope, and the absence of other, essential parts, it has remained until the present time not well understood. Nor is it possible yet correctly to define it in all its details, since in no one species do we know the complete skeleton ; and it is possible, even more, it is probable, that there are two or more concurrent genera among the following species, which may eventually have to

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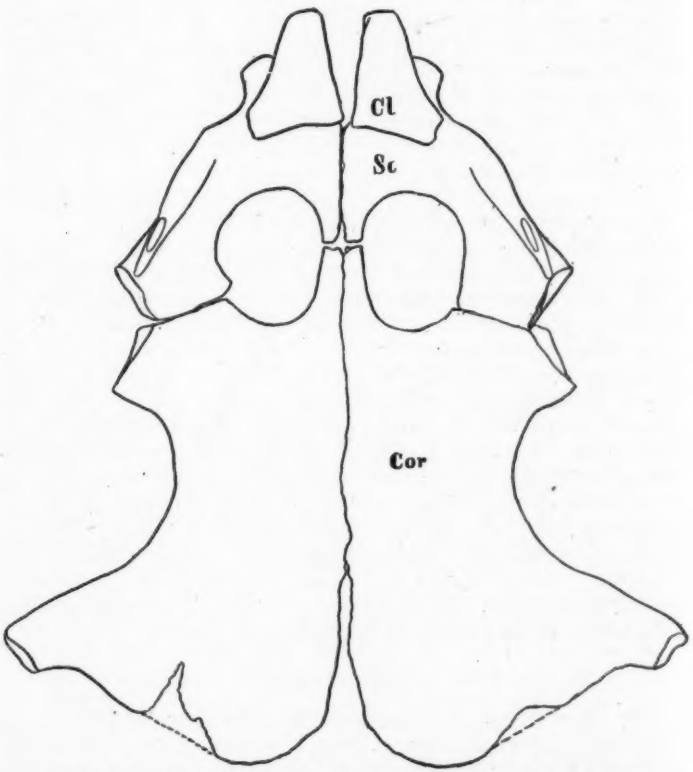

FIGURE 1.—Pectoral girdle of *Cryptoclidus oxoniensis* Phillips. From drawing of articulated specimen, American Museum of Natural History.

be distinguished from each other. Its relationships are nearest with the genus *Cryptoclidus* of Europe, a figure of the pectoral girdle of which, copied from a drawing kindly made for me from an articulated specimen in the American Museum of New York City, is given herewith (text-figure 1). But the two genera are very distinct. Indeed I am not at all sure but

they are distinguishable by more than generic characters, for the family *Elasmosaurus* is a distinct one, though its characters are not quite those assigned to it by Professor Seeley. I may add that so far, from a prolonged study of the American specimens and descriptions, I am of the opinion that no single species of American plesiosaurs can be placed in any known European genus.

Unfortunately, the type specimen of *Elasmosaurus* no longer has the girdles described by Cope. What has become of them is not known. There are some parts of these, especially the clavicular arch, that are necessary for a correct understanding of the genus. However, from an attentive study of this type specimen and of several other specimens which can be with much probability, if not certainty, referred to the same species, I am enabled to give the following characters for the genus *Elasmosaurus*. Those characters derived from the type specimen or type species are given in italics; those derived from other species referred to the genus, in roman:—

Elasmosaurus. Symphysis of mandible short; teeth anisodont. Neck with seventy-six true cervical vertebræ and three pectorals, the centra increasing in length to the fifty-eighth, and then decreasing to the dorsals; thence nearly uniform through the thoracic region; posterior cervicals and dorsals much wider than high, and wider than long; spines of vertebræ wide and not high; zygapophyses weak. Pectoral girdle with large scapulæ meeting each other in the middle line. No interclavicular foramen.

Coracoids broadly separated posteriorly to the interglenoid thickening, the posterior end not much dilated. Cervical ribs single-headed. Ischia short. Skull short; parietal crest much elevated; supraoccipital bones parial; palatines separated by pterygoids. Cervical vertebræ from sixty to seventy-six in number. Scapulæ approaching or meeting in middle line. Propodial bones short; two epipodial bones only, not wider than long; digits much elongated.

Elasmosaurus platyurus Cope. Fort Pierre Cretaceous of Kansas.

A detailed description of this specimen, in completion or correction of that given by Cope, will be given later. Certain measurements and remarks may be appropriate here.

The very broad, depressed, posterior cervical vertebræ of the posterior third, or say the posterior seven feet, prohibited much motion in the living neck, either vertically or horizontally. The motility of the neck practically ceased at the fifty-eighth vertebra. Thenceforward the neck was more slender, very slender toward the head. It was to this part that most, if

not all, motility was confined. The total length of the neck in this species in life, allowing six millimeters only for the thickness of the interarticular cartilages between adjacent vertebræ, was exactly twenty-three feet. A close approximation to the length of the trunk is nine feet; of the tail, eight feet. The length of the head, using *E. snowii* for comparison (and the remains of the type preserved show that there must have been great resemblance between these two forms in the skull), was less than two feet. The entire length of the animal in life, then, was a little over forty-two feet, an estimate somewhat less than that reached by Cope. Other specimens referred to this genus exceeded these dimensions very materially, indicating, if their proportions were alike, an extreme length of not less than sixty feet. The elasmosaurs doubtless were the longest, if not the largest, of all known marine reptiles.

In the extreme elongation of the neck, *Elasmosaurus* exceeded all other vertebrated animals of the past or present, and was, if we assume a diphyletic origin of the short-necked forms, the most specialized of all plesiosaurs, since in no other genus do we know of any species having as many as fifty cervical vertebræ. But I am rather of the opinion that the short-necked types were descendants of earlier and longer-necked forms. Unless this is the case, we know of no early plesiosaurs which could have been the progenitors of such forms as *Polycotylus* with twenty-six cervical vertebræ, or *Brachauchenius* with as few as thirteen. In their paddles, the elasmosaurs were very generalized, in that the epipodials were scarcely broader than long, and their number is but two. In the clavicular arch, *Elasmosaurus* was specialized, while in the coracoids it seems to have retained generalized characters.

As to the habits of these long-necked plesiosaurs in life, I am satisfied that they were in general scavengers, living largely in shallow waters, as well as often out at sea. Numerous remains were found the past season in Wyoming, in the Upper Cretaceous, associated with longirostral and brevirostral amphicœlian crocodiles, dinosaurs, and lepidosteal fishes, as well as with turtles of marsh or fresh-water habit. And especially noticeable was the large number of immature or quite young animals found in these deposits.

It was with a specimen of an elasmosaur (*E. snowii*) that Mudge first noticed the occurrence of the peculiar siliceous pebbles which he described; and it was also with another, a large species yet unnamed, from the Benton Cretaceous, that the like specimens were found described by me in 1892. That this habit was not confined to this type of plesiosaur, however, is certain, since I have also observed it

in different species of *Polycotylus* and *Trinacromerum*, both relatively short-necked and long-headed plesiosaurs. Much doubt and even ridicule have been thrown upon this supposed habit and the use of the pebbles by these reptiles. But the cumulative testimony of writers, both on this and the other side of the Atlantic, is quite conclusive. It has been assumed that the plesiosaurs could not have utilized the pebbles as a means of digestion in a muscular stomach. Dr. Eastman, who has vigorously opposed the idea of the possession of such a bird-like structure on the part of the plesiosaurs, seems to have been quite unaware of the fact that the modern crocodiles have a real, bird-like and muscular gizzard, and so described by Dr. Gadow. The crocodiles have a similar habit, or at least such a habit has been imputed to them, and it is not at all unreasonable to suppose that, strange as it may seem, the plesiosaurs had a real, muscular bird-like gizzard, which utilized the pebbles in whatever way the crocodiles may utilize them.

Elasmosaurus orientalis Cope. Cretaceous of New Jersey.

This species was based upon two mutilated and isolated cervical centra from New Jersey. It seems far more probable that these vertebræ really belong with *Cimoliasaurus*. Cope afterwards associated with this species an excellent series of vertebræ from the Pierre of Montana, which I have studied in the American Museum. I have not the least doubt but that Cope was in error in this collocation. I am not sure of the distinction of this specimen from *E. platyurus*, though a careful comparison of the measurements and sketches made by myself will, I think, decide their identity. If not *E. platyurus*, the species is doubtless entitled to a new specific name.

Elasmosaurus intermedius Cope. Fort Pierre Cretaceous of Montana.

This species was based upon nineteen centra without processes, and all more or less mutilated; now in the museum of the Academy of Natural Sciences at Philadelphia. I can not distinguish them specifically from *E. platyurus*.

Elasmosaurus serpentinus Cope. Niobrara Cretaceous of Nebraska.

This species was based upon much better material than was either of the foregoing ones, and it is both recognizable and distinct. Unfortunately, no figures have ever been given of the type specimen, and I have not had, so far, an opportunity to study the specimen. As in his other descriptions, Cope iden-

tified some of the vertebræ wrongly. The first dorsal vertebra, as he describes it, is in reality a posterior cervical, while his seventh is either the last pectoral or the first true dorsal. From his description, I make out sixty-two as the number of cervical vertebræ preserved, and eighteen dorsals. As this number of dorsals is smaller than is known in any other species of plesiosaurs, I am confident that the series was not complete. If Cope was correct in the serial relations of the cervical vertebræ described, the species is quite distinct from anything otherwise described. His descriptions of the pec-

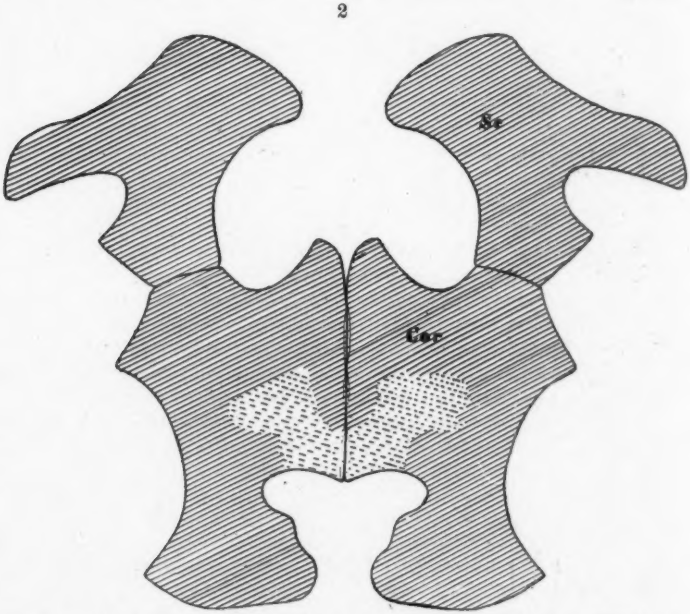

FIGURE 2.—Scapulæ and coracoids of *Elasmosaurus snowii* Williston. Specimen No. 636, Yale Museum.

toral and pelvic girdles and of the limbs indicate an excellent specimen now in the Field Museum, which will be shortly described by Mr. E. S. Riggs, and a perfect humerus from the Hailey shales in the collection of the University of Chicago.

Elasmosaurus snowii Williston. Niobrara Cretaceous of Kansas.

This species, based upon an excellent skull and a connected series of eighteen cervical vertebræ in the museum of the University of Kansas, I identify with much certainty in an

excellent specimen in the Yale collection (No. 1644), collected in 1874, by the late Professor B. F. Mudge, with my assistance, on Plum Creek, in western Kansas. It was the first specimen of plesiosaur that I ever saw. The locality of its collection is only a few miles distant from, and in almost precisely the same horizon as, that of the type specimen of the species, which was obtained from Hell Creek by the late Judge West, in 1890. Fortunately, the Yale specimen has, in addition to numerous vertebræ which quite agree with those of the Kansas specimen, parts of the girdles and limbs. I suspect that the specimen represents a somewhat immature animal; if not, it offers almost generic differences from the *E. platyurus*. The coracoids are of the true elasmosaurian type, that is, with the

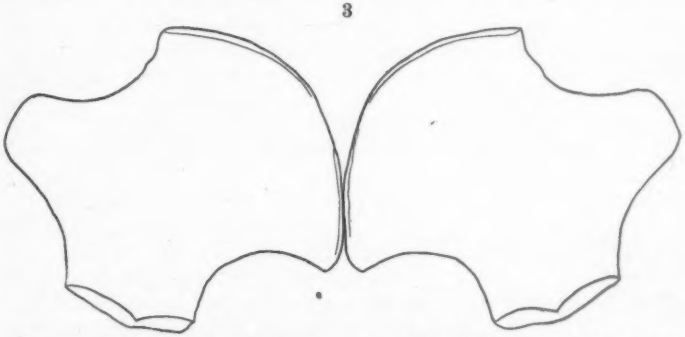

FIGURE 3.—Pubes of *Elasmosaurus snowii* Williston. Specimen No. 636, Yale Museum.

posterior parts broadly separated (text-figure 2), though this part is unusually wide and short. It has, on the other hand, scapulæ of the usual type, not very much widened in the proscapular part. The humerus is quite elasmosaurian also, resembling that of *E. ischiadicus*, though shorter (Plate III, figure 3). The pubis is, however, very distinctive, readily distinguishing the species from *E. ischiadicus*, in that the anterior and external borders are markedly concave, and the symphysial border is much prolonged (text-figure 3). Another specimen of much larger size, in Yale Museum (No. 1641), has a pubis strikingly like this, though the femur is elongated and the epipodials are short.

Elasmosaurus (?) marshii n. sp. Niobrara Cretaceous of Kansas.

The specimen upon which this species is based is No. 1645 of the Yale Museum, collected in 1889 by Mr. H. T. Martin, in the chalk of Logan county, Kansas. It consists of thirty-two vertebræ, a scapula, and a nearly complete fore limb.

The scapula, save the tip of the dorsal process, and the paddle are in excellent preservation. The vertebræ have suffered much from compression, as is usually the case with the soft-boned plesiosaurs in the Kansas chalk.

The scapula is figured in outline herewith (text-figure 4). Its inner part is greatly expanded and produced to meet its mate broadly in the middle line. At their symphysis the two bones are extended backward in a narrow, elongated process, which did not, however, unite with the coracoid, as was the case with *E. platyurus*. In front, the two bones leave a broad, angular interval for the clavicle or interclavicle. Neither of these bones has ever been certainly defined in this genus, though Cope figured the pectoral girdle of *E. platyurus*

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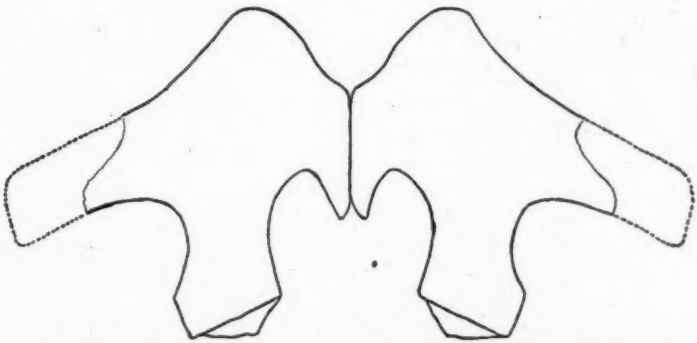


FIGURE 4.—Scapulæ of *Elasmosaurus marshii* Williston. No. 2062, Yale Museum.

as meeting broadly in front, as though the clavicle were fused with the scapulæ. I believe that the missing bone is the interclavicle, and that the clavicles will be found to be as in *Cryptoclidus*.

The structure of the paddle is clearly shown in Plate II, figure 2, as arranged under the supervision of Professor Marsh. I do not know under what conditions the bones were collected, but doubtless they were sent in from the field with the different parts dissociated. A careful study of the mounted specimen, however, assures me of the essential correctness of the restoration. The peculiar form of the humerus, quite unlike that of any other species of plesiosaur known to me, will enable this species to be readily recognized, though the characters of the scapulæ and vertebræ may possibly be insufficient. The bone is short, as is seen,—an elasmo-

saurian character, but it differs from the propodial of any other elasmosaurian known to me, in having an additional facet for a supernumerary epipodial at its distal end. There is, also, an additional mesopodial bone, which is wanting in other species of *Elasmosaurus*. These characters are, I believe, of generic value, but until the structure of the coracoid is known I leave the species provisionally in this genus. The femur has a length of 370^{mm}, and a width of 218^{mm}.

Thirty-three vertebræ are preserved with the type specimen, but as already stated they have suffered much from distortion, and their exact measurements can not be given. They are all clearly from the posterior part of the neck and the dorsal region. Some of the posterior dorsals are missing, though one of the sacrals is preserved. Their characters, so far as they are shown, are clearly elasmosaurian. The ribs are of course single-headed; the spines are broad and not very high; the posterior dorsals are more flattened at their extremities, and their articular rims are sharp, with slight crenulations. The lengths of the centra are given in millimeters, as approximately as the crushed condition will permit, as follows:—

Cervicals: 135, 135, 135, 135, 135, 135, 133, 133, 130, 127, 125, 125, 125, 120.

Dorsals: 115, 115, 115, 112, 110, 110, 100, 95, 90, 90, 90, 90, 90, 90, 90, 90, 85, 80 (sacral).

If this species had similar proportions to those of *E. platyurus*, its length in life was about fifty feet.

Elasmosaurus ischiadicus Williston. Niobrara Cretaceous of Kansas.

Polycotylus ischiadicus Williston, Field Col. Mus. Pub., Geol. Ser., vol. ii, p. 72, pls. x, xxvi, 1903.

This species, based upon the ischia, ilia, caudal and supposed cervical vertebræ, was originally referred provisionally to the genus *Polycotylus* by myself, though gravely doubting its correct location there. An excellent specimen in the Yale Museum (No. 1130), comprising the front paddle nearly complete, a number of vertebræ, and the nearly complete pectoral girdle, seems to be of the same species. I was at one time inclined to the belief that the specimen represented an undescribed species, notwithstanding the resemblance of the ischia, chiefly because of the differences in the structure of the ilia, and because of the characters of the vertebræ which I had identified as cervical. That all the centra preserved in the Kansas specimen are pygals seems hardly possible. If any of them are cervicals, the species are undoubtedly distinct. This question, however, I can not decide until I have had an oppor-

tunity of again examining the type specimen. I therefore place the Yale specimen for the present in this species.

The characters of the pelvis, that is, the short ischia especially, and the shape of the pubis, will be readily appreciated by an examination of Plate I. The paddle is especially noteworthy because of the primitive number of the epipodial bones (there are no supernumeraries), and this character I have also observed in the paddles of three other species of the genus. The paddle, it is also observed, is much elongated, and the femur is relatively short (Plate II, figure 1). The few vertebræ of the neck preserved are quite elasmosaurian in character. Other propodials of this species are preserved in the University of Chicago collections.

Elasmosaurus sternbergi n. sp. Niobrara Cretaceous of Kansas.

The only parts referable with certainty to this species are two complete dorsal vertebræ and some additional fragments in the University of Kansas collection, obtained some years ago by Mr. Charles Sternberg in the yellow chalk of Gove county, Kansas. I describe them, nevertheless, since they indicate the largest plesiosaur of which I have any knowledge. If they belonged to a long-necked form like *E. platyurus*, the animal could not have been less than sixty feet in length. That they pertain to a long-necked form is quite certain, and the general characters of the vertebræ are like those of *Elasmosaurus*.

The dorsal centra are nearly circular in outline, somewhat broader than high, with their sides gently concave. The diapophyses are stout, directed upward and outward to a plane above the zygapophyses. The zygapophyses are separated by a notch and are rather small. The spine is flattened and elongate. Figures of these vertebræ will be given in a later communication.

Width of dorsal centrum	165^{mm}
Height of same	140
Length of same	80
Width of more posterior dorsal	155
Height of same	143
Length of same	78

This is the only specimen referable to this species that I have ever seen in the many years of my acquaintance with the Kansas saurians. Its extreme rarity will therefore justify the description of the rather meager material.

Elasmosaurus nobilis n. sp. Niobrara Cretaceous of Kansas.

A very large specimen referable to a new species is represented by a considerable portion of a skeleton in the Yale

Museum, obtained a good many years ago from the Fort Hays limestone, or basal strata of the Niobrara Cretaceous, of Jewell county, Kansas, by B. F. Mudge. The specimen bears the catalogue number 1640. Unfortunately, the specimen had been injured in collecting before it fell into proper hands. Originally it is probable that the larger part of the pectoral girdle, and perhaps, also, of the pelvic girdle and hind limb had been present, in addition to numerous vertebræ, and all in an undistorted condition. The specimen, notwithstanding what it has suffered, is of much interest, since it is the only vertebrate of which I have any knowledge from the Hays limestone. Additional figures and descriptions will be given later. For the present, the figures of the femur, ilia, and dorsal and sacral vertebræ given in Plate IV will render the species recognizable. A massive fragment of the scapula shows a broad and firm union with its mate in the middle line. The posterior projection of the coracoid is very long and much constricted before its extremity, its distal width being a little less than twice that of its least width; the outer posterior angle is acute and not much produced. The femur shows facets for but two epipodial bones.

Length of femur	337^{mm}
Greatest width distally	206

A rather common species referable to this genus from the fence-post and lower horizons of the Benton is represented by a number of specimens in the Kansas University collections, and will be described later, with figures.

Two additional species also referable to this genus are known to me from the Hailey shales (probably equivalent to the Benton Cretaceous) of Wyoming, and will be described and figured later.

Polycotylus Cope.

The genus *Polycotylus*, described by Cope in 1870 from a number of mutilated vertebræ and fragments of podial bones, has remained hitherto much of a problem, and its characters have been very generally misunderstood. Fortunately, there is an excellent specimen in the Yale Museum (No. 1125), collected now many years ago by the late Professor Marsh in the vicinity of Fort Wallace, Kansas, from the Niobrara chalk, which I believe can be referred with certainty to the type species *P. latipinnis* Cope. That it belongs in the genus *Polycotylus* is beyond dispute, the vertebræ agreeing quite with the type as they do. This species seems to be the most common one of the order in the Kansas chalk, and is represented by several other specimens in the Yale Museum and by specimens in the University of Kansas collection. It is not at

all improbable that the validity of the generic name may be eventually called into question, since there seems to be no difference between the teeth of this form and that described by Leidy years before, from the Cretaceous, presumably Niobrara, of Minnesota, as *Piratosaurus*. However, as the identity must remain for many years, if not always, more or less doubtful, it would be very unwise to make any changes at the present time.

The Yale specimen, presenting as it does not a few interesting morphological and structural characters, will be fully described and figured later. It comprises the larger part of the skeleton, with the lower jaws, parts of the skull, teeth, etc. From the study of this specimen, supplemented by other specimens, clearly conspecific, the generic characters may be stated as follows:—

Polycotylus. Teeth rather slender, with numerous well-marked ridges. Face with slender beak. Cervical vertebræ twenty-six in number; dorsals twenty-eight or twenty-nine, inclusive of three pectorals; all short and all of nearly uniform length. Chevrons articulating in a deep concavity; all the vertebræ, and especially the cervicals, rather deeply concave, and with a broad articular rim. Pectoral girdle with distinct clavicles, interclavicles, and interclavicular foramen; the scapulæ not contiguous in the middle. Coracoid with a long anterior projection, united in the middle, back of the interglenoid bar, to the posterior margin; a foramen on each side, back of interglenoid thickening. Ischia elongated. Paddles with four epipodial bones, all much broader than long.

The foregoing characters, it will be seen, are very much like those already given by me for *Dolichorhynchops*, and I am somewhat in doubt as to the validity of that genus, or rather of *Trinacromerum* Cragin, of which, as I suspected, *Dolichorhynchops* is a synonym. The only important distinctions are the deep concavity of the centra and the mode of articulation of the chevrons. In none of the known species of *Trinacromerum* are there more than three epipodial bones, while in the two species referred to *Polycotylus* there are four well-formed ones. This may be, in addition to the vertebral characters, sufficient to distinguish the genera.

I give herewith some additional figures of *Polycotylus latipinnis*, made from the Yale specimen 1125 (Plate III, figure 1). The pelvic girdle, as will be seen, is remarkable for the great elongation of the ischia. The paddle figured by me in my previous paper on the plesiosaurs* was correctly assigned to the species, but is a hind paddle instead of a pectoral limb.

*Field Col. Mus. Pub., Geol. Ser., vol. ii, pl. xx.

A front paddle preserved in the Yale collection, has, as usual, the humerus more expanded distally. An outline of the coracoids and scapulæ, as preserved, is given in text-figure 5.

Polycotylus dolichopus n. sp. Niobrara Cretaceous of Kansas.

A species quite distinct from *P. latipinnis* is represented in the Yale collection by two specimens, the one a femur and most of the paddle (No. 1642), the other a humerus and some

5

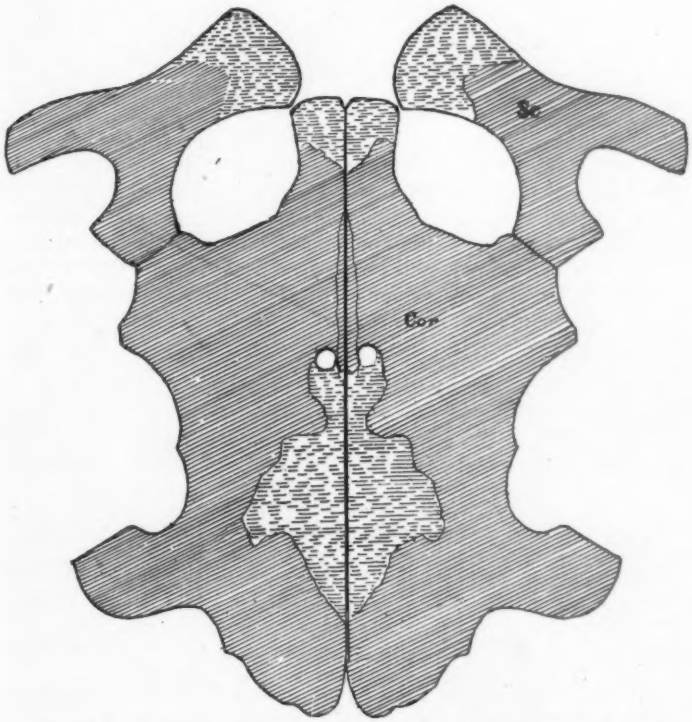


FIGURE 5.—Scapulæ and coracoids of *Polycotylus latipinnis* Cope. No. 1125, Yale Museum.

of the mesopodial and epipodial bones (No. 1646), both from the Niobrara chalk of Kansas.

I am convinced that these two specimens are conspecific, judging especially from the shape of the epipodials, but in the possibility that they may prove to be distinct, specimen No. 1646 may be considered the type of the species. The species is especially characterized by the slenderness of the shaft of

the propodials, the great transverse dilatation of the epipodials, and the markedly greater concavity of the posterior border of the propodials (Plate III, figure 2). The metapodials and phalanges are also notable for their shortness and robustness. There are four facets on the distal extremity of the propodials for articulation with the epipodials.

Length of femur (No. 1642)	311^{mm}
Greatest distal expanse	154
Length of humerus (No. 1646)	317
Greatest distal expanse	172

An additional species of this genus is known to me, and will be figured and described in a later communication.

Trinacromerum Cragin.

The genus *Trinacromerum*, if it be distinct from *Polycotylus*, as I believe that it is, is represented in the Yale collection by a considerable portion of a skeleton (No. 1129), clearly identifiable with *T. anonymum* Williston, from the Benton Cretaceous. This specimen, which offers some additional facts of interest, will be figured and described in a later communication, in connection with the description of the type species of the genus, *T. bentonianum*, which I have recently studied in the Colorado College collection.

EXPLANATION OF PLATES.

Plate I.

Pelvic girdle of *Elasmosaurus ischiadicus* Williston. *p*, pubis; *il*, ilium; *is*, ischium. Specimen No. 1130, Yale Museum.

Plate II.

Figure 1.—Right pelvic paddle of *Elasmosaurus ischiadicus* Williston. Specimen No. 1130, Yale Museum.

Figure 2.—Left pectoral paddle of *Elasmosaurus (?) marshii* Williston. Specimen No. 1645, Yale Museum.

Plate III.

Figure 1.—Left half of pelvic girdle of *Polycotylus latipinnis* Cope. 1*a*, pubis; 1*b*, ischium; 1*c*, ilium. Specimen No. 1125, Yale Museum.

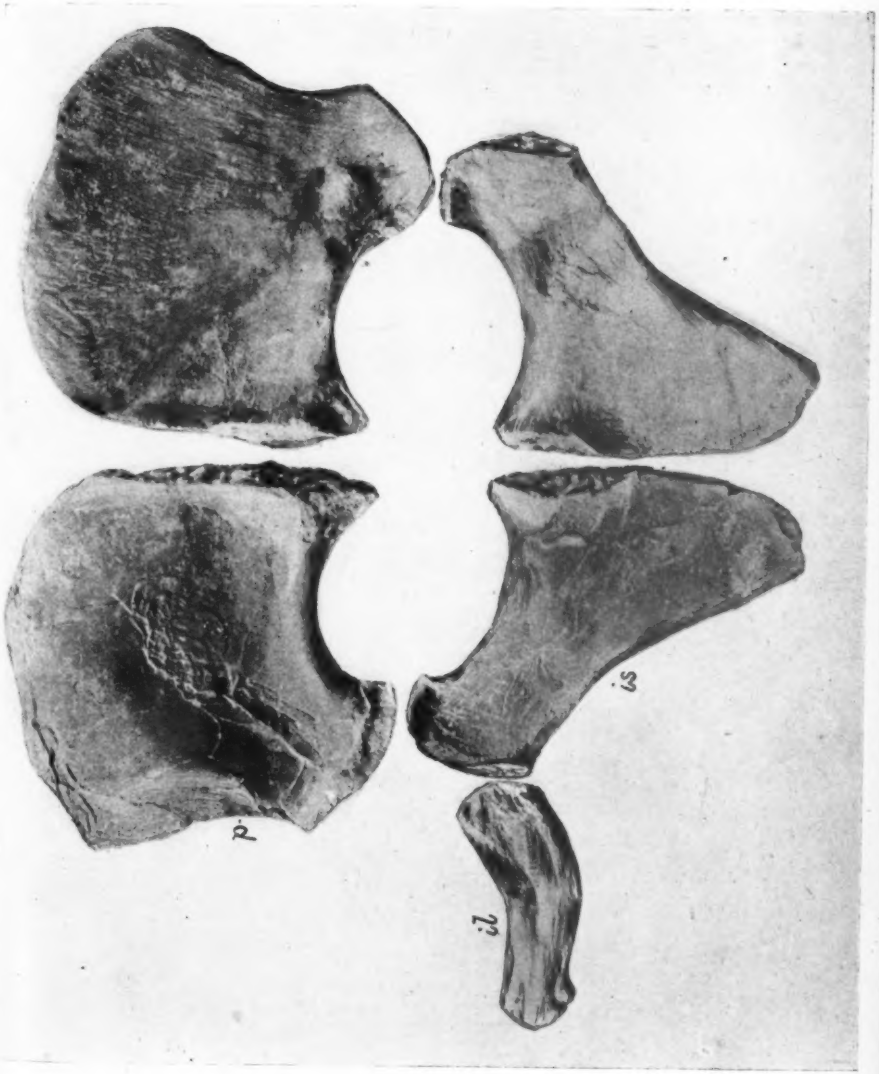
Figure 2.—Right propodial and epipodial bones of *Polycotylus dolichopus* Williston. Specimen No. 1642, Yale Museum.

Figure 3.—Right humerus of *Elasmosaurus snowii* Williston. Specimen No. 1644, Yale Museum.

Plate IV.

Elasmosaurus nobilis Williston. Specimen No. 1640, Yale Museum.

Figure 1.—Right ilium.
Figure 2.—Left ilium.
Figure 3.—Right femur.
Figure 4.—Posterior sacral vertebra.
Figure 5.—First sacral vertebra.
Figure 6.—Anterior dorsal vertebra.
Figures 7, 8.—Posterior dorsal vertebræ.
Figure 9.—Middle sacral vertebra.



Elasmosaurus ischiadicus Williston.

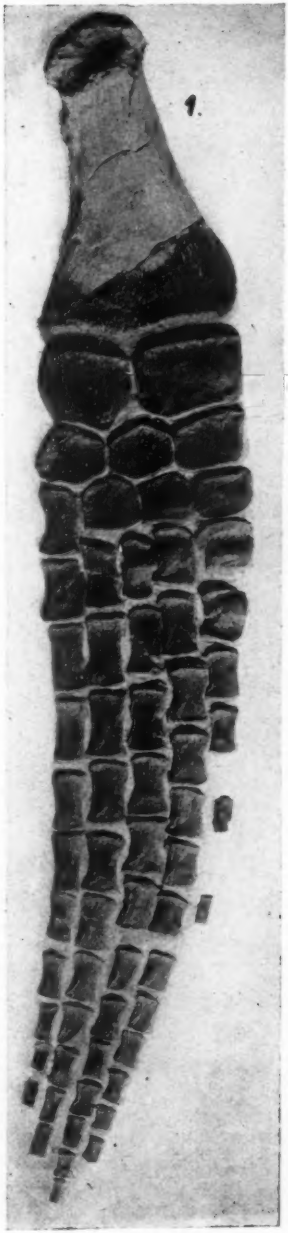


FIG. 1. *Elasmosaurus ischiadicus* Williston.
FIG. 2. *Elasmosaurus*(?) *marshii* Williston.

FIG. 1. *Polycotylus latipinnis* Cope. FIG. 2. *P. dolichopus* Williston.
FIG. 3. *Elasmosaurus snowii* Williston.

Elasmosaurus nobilis Williston.

Art. XVII.—*The Occurrence of Sulphur and Celestite at Maybee, Michigan;* by E. H. Kraus and W. F. Hunt.

A. *Relation of Celestite-bearing Rocks to Occurrences of Sulphur and Sulphureted Waters.*

That celestite-bearing rocks occur quite extensively in New York and Michigan has been recently pointed out.* Perhaps one of the best localities to study these rocks in respect to the formation of sulphur and sulphureted water is at the Woolmith quarry, midway between the towns of Scofield and Maybee, Monroe Co., Michigan.

Inasmuch as Sherzer† has reported in detail concerning the geology of this locality, it is sufficient to say that the nine different beds exposed at this quarry are assigned to the Monroe series, perhaps the equivalent of the Salina in New York. The rocks are for the most part dolomites, sometimes, however, quite siliceous. Many of the strata also contain a relatively large per cent of bituminous matter. It is also important to state that the strata at or near the surface are usually quite compact and vary much in color—from gray to brown—and are more or less blotched or streaked. These compact layers are characterized by an unusually high specific gravity. But since the rocks are not homogeneous, different values were obtained, ranging from 2·80 to 3·45, which are for the most part considerably higher than that of a normal dolomite, namely 2·80 to 2·90. This high specific gravity must, hence, be considered as indicative of the presence of some mineral, possessing quite a high specific gravity, disseminated throughout the rock.

As one descends into the quarry the rocks become more porous and cavernous. It is in these layers with cavities ranging from a few inches up to a foot or more in diameter that the native sulphur with its usual associates, celestite, calcite, and sometimes gypsum, is found. The occurrence of these minerals is clearly one of secondary formation.

The rocks near the surface, although compact where they have been protected, show, when exposed, the characteristic structure of leached celestite-bearing rocks. This, together with the high specific gravity already referred to it, would suggest the presence of celestite. In order to determine the presence of the mineral and also its probable percentage, an

* E. H. Kraus, "Occurrence of Celestite near Syracuse, N. Y., etc.," this Journal (4), xviii, 30–39, 1904; also "Occurrence and Distribution of Celestite-bearing Rocks," this Journal (4), xix, 286–293, 1905.

† "Geological Report on Monroe County," Geological Survey of Michigan, 1900, 75.

analysis of the uppermost layer, characterized as Bed A by Sherzer, was made.

As already indicated, this rock is by no means homogeneous and, hence, in order to obtain as near as possible the average composition of the same, many chips were taken from a specimen of approximately the following dimensions, $4 \times 5 \times 6$ inches. The specific gravity of most of the chips was determined and the following are some of the values obtained: 2·80, 2·87, 2·98, 3·17, 3·33, and 3·45.

The methods pursued in this and the following analyses were those recommended by Hillebrand.* Knowing that much would depend upon the careful separation of the earth alkalies, the utmost care was exercised in their determination. The precipitates were in every instance tested spectroscopically and, if necessary, the extraction repeated until in each case they could be considered free from contamination. We may, therefore, regard the results obtained as very accurate. They are as follows:

	Per cent.	Ratio.
SiO_2	0·58	
Al_2O_3, Fe_2O_3	0·37	
CaO	25·18	0·44884
MgO	18·11	0·44871
BaO	0·13	0·00085
SrO	*7·86*	0·07587
Na_2O	0·11	
K_2O	0·05	
P_2O_5	0·02	
Cl	0·04	
CO_2	39·55	0·89886
SO_3	*6·33*	0·07907
Organic matter	0·92	
H_2S	trace	
Total	99·25	

The percentages of the oxides of calcium, magnesium, strontium, and barium, together with the carbon dioxide and sulphur trioxide, are important. It is at once noticeable that the amounts of strontium oxide and sulphur trioxide are relatively high. A comparison of the combined ratios of the oxides of calcium and magnesium with that of the carbon dioxide,

$$\left\{\begin{matrix}\text{CaO}\ (\cdot44884)\\ \text{MgO}\ (\cdot44871)\end{matrix}\right\} : CO_2\ (\cdot89886) = 1 : 1\cdot0014,$$

shows that the rock is essentially a dolomite and, in fact, a normal dolomite. We, thus, have quite conclusive evidence

* Bulletins 148 and 176, U. S. Geological Survey.

that all of the calcium and magnesium oxides are doubtlessly present as carbonates and not in part as sulphates.

The unusually high percentages of strontium oxide and sulphur trioxide are extremely interesting. If we consider the small amount of barium oxide present as isomorphous with the strontium oxide, we obtain the following proportion :

$$\left.\begin{matrix} \text{SrO } (\cdot 07587) \\ \text{BaO } (\cdot 00085) \end{matrix}\right\} : \text{SO}_3\ (\cdot 07907) = 1 : 1 \cdot 0306.$$

These values would indicate that the sulphur trioxide is combined with the oxides of strontium and barium and, hence, evidence is at hand that the mineral celestite is present in this uppermost layer to the extent of *14·32* per cent. The results of the analysis are, therefore, in harmony with what has already been said concerning the structure and specific gravity of the rock.

The very small amount of the combined oxides of aluminium and iron, namely 0·37 per cent, would preclude any appreciable quantity of pyrite or marcasite being present. It is, however, significant, as will be seen later, that organic matter and a trace of hydrogen sulphide were noted.

Descending into the quarry, not only do the strata become more porous and cavernous but at various levels water containing a considerable amount of hydrogen sulphide is encountered. As said, the porous layers contain native sulphur associated with celestite. Sherzer in discussing the probable origin of the sulphur at this quarry rightly refers the same to the hydrogen sulphide, which is to be observed to a very large extent in Southern Michigan. In the immediate vicinity of the Woolmith quarry most of the wells show varying amounts of it. These wells are from 18 to 20 feet deep and after passing through the drift penetrate rock to the extent of two to four feet. The layer, which is doubtlessly encountered, is the one called Bed A, an analysis of which was just given.

Sherzer thought that the hydrogen sulphide might be due to the decomposition of pyrite and marcasite, which were supposed by him to be present in considerable quantities. The analysis of the rock of Bed A, however, shows clearly that if these sulphides of iron are present in the upper strata, they must be present in amounts which are almost insignificant when compared with that of strontium sulphate. In some of the lower layers, in a few instances, pyrite has been noticed but always in very small amounts. Its occurrence is also clearly secondary. Without a doubt we are dealing with descending waters at this locality.

It is also of vast importance to call attention to the fact that when the rocks of the various layers in this quarry—the same

holds good of many of the celestite-bearing rocks of central New York—are treated with dilute acid, hydrogen sulphide is liberated together with the carbon dioxide. Even boiling in water is sufficient to give rise to the liberation of the sulphureted hydrogen. To be sure, in some instances, the amount is very small, but, nevertheless, even a trace is of great import, indicating that a sulphide decomposed by hot water is present. Such a sulphide is doubtlessly strontium sulphide. Hence, we must consider the theory that the decomposition of pyrite or marcasite by the formation and subsequent oxidation of hydrogen sulphide has given rise to the native sulphur at this quarry as untenable.

However, when we consider that the uppermost strata contain about 14 per cent of strontium sulphate, which is quite soluble in water and, hence, easily transported to the lower layers, and, secondly, that these and the lower strata contain considerable quantities of organic matter; thirdly, that there is only a negligible amount of iron present, and lastly, that hydrogen sulphide is easily liberated by hot water, it seems evident that the celestite, present in a disseminated condition and which has by the action of the organic matter become partially reduced to the sulphide, must be considered as the source of the hydrogen sulphide.

Therefore, if the foregoing statements be true, an analysis of one of the more porous and cavernous layers, the cavities of which contain native sulphur, ought to show not only the presence of strontium as a sulphate but also as a sulphide, which would be indicated in the analysis as sulphur trioxide and sulphur, respectively. Such an analysis was made with the following results:

	Per cent.	Ratio.
SiO_2	20·14	
Fe_2O_3, Al_2O_3	0·86	
CaO	19·56	0·3493
MgO	15·32	0·3795
SrO	0·66	0·006371
BaO	0·07	0·000457
S	0·02	0·000587
SO_3	0·56	0·006994
CO_2	31·94	0·7259
Na_2O	0·09	
K_2O	0·07	
Cl	0·03	
Organic matter*	10·72	
	100·00	

* By difference after deducting the oxygen equivalent of the sulphur.

The sulphur was calculated from the hydrogen sulphide obtained directly by the liberation with hydrochloric acid, absorbed in potassium hydroxide, acidified and titrated with $\frac{N}{100}$ iodine solution.

The silica is present, no doubt, as free silica. The value of the ratios of the oxides of the calcium and magnesium, as also that of the carbon dioxide, give the following proportion :

$$\left\{\begin{matrix} CaO & (\cdot 3493) \\ MgO & (\cdot 3795) \end{matrix}\right\} : CO_2\ (\cdot 7259) = 1\cdot 004 : 1.$$

Hence, this rock may be considered as a siliceous dolomite. The sulphur trioxide represents the total amount of sulphur present as sulphate and sulphide, whereas the hydrogen sulphide is to be considered as being derived from a sulphide only. Hence, if we consider the hydrogen sulphide as being due to the decomposition of the strontium sulphide and, therefore, deduct from the percentage of strontium oxide given in the analysis, the amount necessary to unite with the 0·02 per cent of sulphur* to form strontium sulphide, the following relationship between the ratios of the strontium and barium oxides and the sulphur trioxide, actually present, is revealed :

$$\left\{\begin{matrix} SrO \\ BaO \end{matrix}\right\} \cdot 006174 : SO_3\ \cdot 00516 = 1\cdot 099 : 1.$$

These values are so close that we must consider the evidence in support of the above theory as very conclusive, namely, that the celestite as the source of the sulphur is partially reduced to strontium sulphide, which, when acted upon an acid and even by water under certain conditions,† will liberate hydrogen sulphide. Oxidation of the hydrogen sulphide will, of course, then give rise to the sulphur. That the sulphur should be associated with celestite is from the foregoing self-evident.

Osann,‡ in reviewing Sherzer's theory of the origin of sulphur at the Woolmith quarry, suggested that it was doubtlessly due to the reduction of the strontium sulphate, as is now revealed by the analysis above to be the case. As to how the strontium sulphate has been reduced to the sulphide, nothing definite can be said at this time. Doubtlessly, it is the result of the action of the organic matter present, which may in some cases be quite high. Whether organic matter alone, or perhaps with moisture, but unaided by bacteria, can cause a reduction of the sulphate, is now being investigated.

* Determinations from other portions of this same layer showed as much as 0·12 per cent hydrogen sulphide. The analysis was, however, not complete and, hence, is not given. These figures show, nevertheless, that sulphureted hydrogen may be liberated in appreciable amounts.

† Compare Bischof's Chemische Geologie, 1863, i, 833.

‡ Groth's Zeitschrift für Krystallographie, etc., xxviii, 321, 1897.

The formation of hydrogen sulphide in this way is of great importance, for no doubt many of the sulphureted waters encountered in localities where celestite-bearing rocks have been noted are to be referred to the above process. These rocks are quite common in southern Michigan and here we also find many so-called "sulphur" wells.

The formation of sulphur by the reduction of celestite is analogous to the process which by many is supposed to have played an important rôle in forming the enormous deposits at Girgenti and vicinity on the Island of Sicily. Here it is, however, assumed that gypsum ($CaSO_4$, $2H_2O$) has been reduced to the sulphide and then hydrogen sulphide liberated and subsequently oxidized.*

B. *Crystallography of the Celestite.*

As already shown, in the cracks, crevices, and cavities† of the lower strata at this quarry beautiful crystallizations of celestite are to be observed. Since crystals of celestite from this locality had not as yet been measured, a large number were collected with this in view.

The crystals were for the most part clear and transparent, possessing a slight bluish tint. The faces were bright and the images, on the whole, very good, so that measurements could be made with very great accuracy.

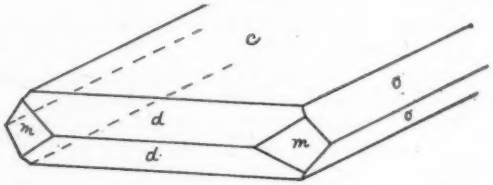
Two distinct types of crystals were observed and measured. Figure 1 represents the tabular variety. These crystals were about 10^{mm} in width and 2^{mm} thick and showed the following forms: $c\{001\}$, $m\{110\}$, $d\{102\}$, and $o\{011\}$. The other, prismatic, type is represented by figure 2. These were about 6^{mm} wide and 4^{mm} thick and showed the following additional forms: $a\{100\}$, $b\{010\}$, $n\{120\}$, and $z\{111\}$. On the prismatic type the pyramid $y\{122\}$ was also observed, but the images obtained were rather poor and, hence, the readings somewhat doubtful. On a few crystals the pyramid $L\{10{\cdot}55{\cdot}44\}$, $\frac{5}{4}P^{11}_{2}$, was noted, which up to now has not been observed on celestite. Although the indices are large, the reflections were of such a character that no mistake could have been made in the identity of the form. Also on several crystals a small prism face (410) was recorded. In this case, the readings are not to be considered as accurate as in the case of the pyramid just referred to, but nevertheless this prism, which is also new on celestite, must be considered as present. Although this form had not been noted on celestite before, it has been observed on barite.

* Brauns, Chemische Mineralogie, 1896, 384 and 389; also Kemp, The Mineral Industry, 1893, 585.

† This Journal [4], xix, 1905, 290.

As shown in the figures, the crystals were developed on one end only, having occurred attached.

1



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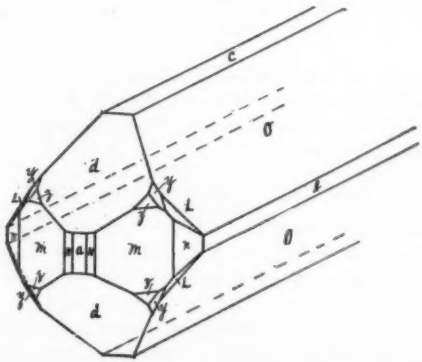


The forms observed are $a\{100\}$, $b\{010\}$, $c\{001\}$, $m\{110\}$, $n\{120\}$, N$\{410\}$, $z\{111\}$, $y\{122\}$, L$\{10{\cdot}55{\cdot}44\}$, $o\{011\}$, $d\{102\}$.
The measurements are as follows:

Crystal system—Orthorhombic (holohedral).

Axial ratio : $a : b : c = {\cdot}7781 : 1 : 1{\cdot}2673$.

				Observed.		Calculated.	
$m : m =$	(110)	:	$(1\bar{1}0) =$	75°	46½′*	------	
$d : d =$	(102)	:	$(\bar{1}02)$	78	43*	------	
$n : n =$	(120)	:	$(\bar{1}20)$	65	28	65°	27′
$o : o =$	(011)	:	$(0\bar{1}1)$	103	56	103	50
$c : z =$	(001)	:	(111)	64	17½	64	18
$c : y =$	(001)	:	(122)	56	26	56	36
$c : L =$	(001)	:	(10·55·44)	58	44	58	36
$z : z =$	(111)	:	$(\bar{1}11)$	90	32	90	40
$z : z =$	(111)	:	$(1\bar{1}1)$	67	17½	67	12
$L : L =$	(10·55·44)	:	$(10{\cdot}\bar{5}5{\cdot}44)$	112	6	112	26
$m : d =$	(110)	:	(102)	59	59	59	58
$m : o =$	(110)	:	(011)	61	1	61	6
$N : N =$	(410)	:	$(4\bar{1}0)$	22	32	22	1

C. *Chemical Composition of the Celestite.*

A number of clear, transparent crystals were selected for an analysis and the following results obtained:

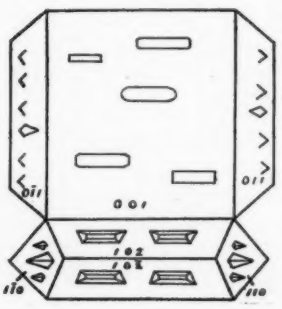
	I.	II.	Average.
SiO_2	0·22	0·23	0·225
Fe_2O_3 } Al_2O_3 }	0·15	0·13	0·140
CaO	0·45	0·47	0·460
MgO	0·12	0·14	0·130
BaO	1·26	1·32	1·290
SrO	53·75	53·78	53·765
SO_3	43·58	43·60	43·590
	99·53	99·67	99·600

The measured crystals possess a specific gravity of *3·979*. The determinations were made by means of the hydrostatic balance at a room temperature of 19·5 C., while that of the water was 20·5° C.

D. *Natural Etch Figures on Celestite.*

While examining the crystals from the Woolmith quarry, it was observed that many of the faces showed natural etch figures. Closer examination, however, showed that these figures could not be studied as well as those noted on some crystals obtained from the Island of Put-In-Bay, Lake Erie, where celestite also occurs in large quantities.

3



The natural etch figures are well defined and their form as well as their position on the various faces show conclusively the symmetry of the holohedral class of the orthorhombic system. Figure 3 shows these figures upon a crystal from Put-In-Bay. In form and distribution they are very similar to the artificial etch figures observed by Prendel.* The solvents used by Prendel were sulphuric acid in one case and potassium carbonate and hydrochloric acid in the other. To our knowledge, natural etch figures on celestite have never been described.

We are indebted to Prof. E. D. Campbell, Director of the Chemical Laboratory of this University, for valuable suggestions relating to the chemical portion of this paper.

Mineralogical Laboratory, University of Michigan,
Ann Arbor, Mich., November, 1905.

*Cölestin von Dorfe Dorobany bei der Stadt Hotin, Gouvernement Bessarabien, Groth's Zeitschrift für Krystallographie, etc., 1898, xxx, 319.

ART. XVIII—*Local Predictions for the Total Eclipse of the Sun, 1907, January 13–14, in Turkestan and Mongolia;* by DAVID TODD and ROBERT H. BAKER.

[Contributions from Amherst College Observatory—lxxiii.]

SIX total eclipses of the sun happen during the next six years, and it might be expected that contributions to knowledge of the corona would be correspondingly ample.

Of these eclipses, however, the tracks of those of 1908 and 1911 are wholly confined to the Pacific Ocean, with the possibility of observing stations on only two or three difficult islands; the eclipse of 1909 is too near the north pole and that of 1910 too near the south pole for ready observation; totality of 1912 can perhaps be excellently obtained in Brazil;* but of them all, that of 1907 seems least uncertain to yield significant results.

Following the last eclipse (1905, August 30) by an interval of seventeen months, the figure and type of the corona will doubtless have changed completely; so that it is in the highest degree important to photograph this totality.

Fortunately, the track of the eclipse of 1907, January 13–14, is wholly on land. But a good part of the region visited is so remote and difficult of access, in Mongolia and the Gobi desert, that it can be occupied only by equipping tedious and expensive expeditions. Only one station in Mongolia, Tsairosu (see table below given), seems likely to be considered.

But the western half of the track crosses Turkestan, a trans-Caspian region penetrated by the imperial railways of Russia. For travelers from the United States, it can readily be reached by Naples, Constantinople, the Black Sea, Tiflis, the Caspian Sea, Bokhara and Samarkand.

For Europeans a convenient route would be Berlin, Warsaw, Moscow, Samara, Orenburg and Tashkent. On this railway and about two-thirds of the way from Tashkent to Samarkand lies Jizak, only a few miles from the exact line of central eclipse. Other easily accessible places near Jizak, and well within the belt of totality, are Zaamin, Nau and Ura-tiube. The last is practically central. If we go farther east, the track of the eclipse leads into a region more and more difficult in every way, although the totality is a few seconds longer there, and the eclipsed sun a few degrees higher.

In order to exhibit the exact circumstances of the eclipse, throughout the entire length of its track, the indicated data have been calculated for eleven stations, as exhibited in the following table. Also the results of the calculated example in the British Nautical Almanac, for a station between Yarkand and Cherchen, are included.†

The computations are based on the Besselian elements of the American Ephemeris, and the geographical positions of the towns have, for the most part, been obtained from a map recently published by the Carnegie Institution of Washington.‡

* Todd, Total Eclipses of the Sun (Boston, 1900), p 249.

† The Nautical Almanac for the Meridian of Greenwich, 1907, p. 594–5.

‡ Pumpelly and Davis, Explorations in Turkestan (Washington, 1905), p. 157.

Total Solar Eclipse, January 13–14, 1907.

Name of station.	Miles from central line.	Latitude north.	Longitude E. from Greenwich.	Eclipse begins.	Totality begins.	Totality ends.	Eclipse ends.
				Local mean time.			
TURKESTAN.							
Chimbai	3 S.	42° 56′	59° 49′	20h 8m 42s	21h 19m 0·8s	21h 20m 45·1s	22h 38m 58s
Jizak	13 S.	40 8	67 48	20 44 50	21 59 58·4	22 1 55·2	23 23 47
Zaamin	15 S.	39 56	68 26	20 47 49	22 3 19·5	22 5 17·7	23 27 31
Ura-tiube	2 S.	39 59	69 0	20 50 52	22 6 37·1	22 8 40·9	23 31 1
Nau	14 N.	40 8	69 22	20 52 56	22 9 10·5	22 11 5·1	23 33 21
Sanku	12 S.	39 15	71 13	21 1 38	22 18 49·6	22 20 58·0	23 44 25
E. TURKESTAN.							
Tagharma Peak	2 S.	38 30	74 32	21 19 56	22 39 10·3	22 41 18·2	0 6 7
Posgam	8 S.	38 15	77 19	21 33 37	22 54 21·4	22 56 39·2	0 22 1
Yarkand	4 N.	38 25	77 21	21 33 37	22 54 37·4	22 56 54·5	0 22 11
.....	3 N.	38 12	79 54	21 45 18	23 10 1·0	23 12 21·0	0 37 6
Cherchen	3 S.	38 2	85 33	22 20 39	23 44 50·8	23 47 12·6	1 12 31
MONGOLIA.							
Tsair-osu	2 N.	44 43	106 41	0 29 58	1 49 41·6	1 51 36·7	3 5 56

	Duration of totality.	Angle of position (direct image) First contact. From N. Pt. toward E.	At middle of eclipse. Sun's azimuth.	At middle of eclipse. Sun's altitude.
TURKESTAN.				
Chimbai	1m 44·3s	271·9°	319° 45′	14° 47′
Jizak	1 56·8	271·3	328 3	21 34
Zaamin	1 58·2	271·2	328 47	22 4
Ura-tiube	2 3·8	270·9	329 33	22 21
Nau	1 54·6	270·6	330 10	22 29
Sanku	2 8·4	270·8	332 14	24 9
E. TURKESTAN.				
Tagharma Peak	2m 7·9s	270·2°	336° 44′	26° 27′
Posgam	2 17·8	270·4	340 44	27 50
Yarkand	2 17·1	270·3	340 48	27 41
.....	2 20·0	267·0	....	....
Cherchen	2 21·8	267·3	353 55	30 14
MONGOLIA.				
Tsair-osu	1 55·1	261·5	25 14	19 23

Observatory House, Amherst, Mass., 31st January, 1906.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Silicon-fluoroform.*—By the action of silicon-chloroform upon tin and titanium fluorides, Ruff and Albert have succeeded in preparing the hitherto unknown silicon-fluoroform, $SiHF_3$. Titanium fluoride is preferable to the tin compound for the preparation of the new compound. The reacting substances were heated in a copper bomb or in a well dried sealed-tube of glass for 18 hours at 100–120°, and the resulting product was collected by condensing with liquid air. The reaction is as follows:

$$3TiF_4 + 4SiHCl_3 = 4SiHF_3 + 3TiCl_4.$$

Silicon-fluoroform is a colorless gas which forms a liquid boiling at −80° and solidifying at about −110°. When brought into contact with sodium hydroxide solution it is decomposed with the liberation of an equal volume of hydrogen, according to the equation

$$SiHF_3 + 3NaOH + H_2O = Si(OH)_4 + 3NaF + H_2.$$

When heated in a closed tube to about 420° the gas is decomposed with deposition of silicon as follows:

$$4SiHF_3 = 2H_2 + 3SiF_4 + Si.$$

It is combustible in the air, and forms explosive mixtures with the same, possibly according to the equation

$$12SiHF_3 + 6O_2 = 3SiF_4 + 3SiO_2 + 4H_2SiF_6 + 2H_2SiO_3.$$

The preparation of silicon-fluoroform completes a series of halogen compounds in which the boiling-point rises rapidly with the atomic weight of the halogen as follows:

Compound,	$SiHF_3$	$SiHCl_3$	$SiHBr_3$	$SiHI_3$
Boiling-point,	−80°	+33°	about 110°	about 220°

—*Berichte*, xxxviii, 52. H. L. W.

2. *Decomposition of Ammonium Sulphate by Hot Sulphuric Acid in the Presence of Platinum.*—It has been shown by Delépine that the use of platinum sponge for regulating the boiling in the determination of nitrogen by Kjeldahl's method leads to a large or even a total loss of the ammonia. This fact has been confirmed by von Dam, who has shown that nitrogen gas escapes during the operation. The subject has now been studied further by Delépine, and the reaction has been satisfactorily explained by him. It was found that metallic platinum dissolves in strong, hot sulphuric acid, and that this solvent action does not depend upon the presence of nitrous acid as has been supposed. It was found also that in the presence of ammonium sulphate platinum sponge does not lose weight appreciably when treated with the hot acid, and it was shown that nitrogen gas and sulphur dioxide

were evolved under these circumstances in amounts exactly corresponding to the equation

$$(NH_4)_2SO_4 + 2H_2SO_4 = N_2 + 3SO_2 + 6H_2O.$$

The part played by the platinum in the reaction is shown by the following equations:

$$4H_2SO_4 + Pt = Pt(SO_4)_2 + 2SO_2 + 4H_2O;$$
$$3Pt(SO_4)_2 + 2(NH_4)_2SO_4 = 2N_2 + 3Pt + 8H_2SO_4.$$

The truth of this interpretation was shown by the fact that a colored solution is obtained by treating platinum with sulphuric acid, and that this solution deposits most of its platinum when it is heated with ammonium sulphate. There is a further, indirect proof in the fact that sponges of metallic gold and iridium, which do not dissolve in sulphuric acid, cause no loss of ammonia under similar treatment.—*Bulletin*, xxxv, 8. H. L. W.

3. *The Determination of Tellurous and Telluric Acids.*—To make these determinations Berg places the substance in a porcelain boat in a combustion tube which is drawn out in front, bent downward, and connected with two small U-tubes each containing 5^{cc} of water. Gaseous hydrochloric acid is then passed through the tube, and when the air has been expelled, the tube is rapidly heated below redness, while the current of gas is moderated, and thus tellurous chloride is formed and collected in the receivers. The liquid is transferred to a weighed porcelain capsule, 5^{cc} of pure nitric acid are added, the liquid is evaporated on a sand bath, and the residue is heated cautiously to decompose the basic tellurous nitrate without fusing the resulting oxide. Tellurous oxide is then weighed. When certain salts are thus analyzed, the metallic chloride remaining in the boat may be weighed. The author gives some satisfactory results obtained by this method.—*Bulletin*, xxxiii, 1310. H. L. W.

4. *Manganese as a Fertilizer for Plants.*—The view was formerly held that the small quantities of manganese present in vegetable and animal substances were accidental and unnecessary, but recently many investigations have indicated that this metal is indispensable to the living cell. Bertrand has recently shown by field experiments that the application of pure manganese sulphate to the soil at the rate of 50^{kg} per hectare showed a marked fertilizing effect upon a crop of oats, amounting to an increase of 22·5 per cent in the yield. An analysis of the crops to which manganese was applied showed no increase in its contents of the metal over the crop to which none was applied.—*Comptes Rendus*, cxli, 1255. H. L. W.

5. *Conversations on Chemistry*, by W. Ostwald. Authorized translation by Stuart K. Turnbull. Part II, *The Chemistry of the Most Important Elements and Compounds.* 12mo, pp. 373. New York, 1906, John Wiley & Sons.—The first volume of this work, by another translator, was recently noticed in this department of the Journal. Like its predecessor, the second part has many interesting and excellent features, and if the old conversa-

tional plan here adopted is approved, the book will be a good one for younger students of chemistry. H. L. W.

6. *Experimental Electro-Chemistry*, by N. Monroe Hopkins. 8vo, pp. 284. (D. Van Nostrand Co., 1905.) Price, $3.00 net.—As the name indicates, this book deals more particularly with experimental electro-chemistry. The theory of electrolytic dissociation is presented with some experimental evidence to support it. Detailed directions are given for a number of electrolytic preparations. The action of primary and secondary cells is discussed and illustrated by experiments. An excellent bibliography of the more important works on electro-chemistry is given at the end. There are some rather surprising omissions. Thus, while two chapters are devoted to the theory of electrolytic dissociation, there is hardly a mention made of the electrical methods of measuring dissociation. Instead, the method depending on the depression of the freezing point is described in some detail, though this method is hardly to be classed under electro-chemistry.

H. W. F.

7. *Radiation from Ordinary Materials.*—Norman B. Campbell sums up a paper on this subject, containing the results of work done in the Cavendish Laboratory, as follows: "If the object of this paper has been attained, it has been proved beyond doubt, that the emission of ionizing radiation is an inherent property of all the metals investigated; and I see no reason why it should not be extended to all substances. It is not of course necessary that this ray emission should be identified at once with radio-activity—if that word be taken to mean a process of ray emission accompanied by atomic change. But the constant intensity of the rays and the probability that the greater proportion of them are α rays, which is suggested by the investigation of their charge and their penetration, afford considerable support for that hypothesis; while I know of no other process which affords any analogy. But before the identity can be established irrefutably further work is required, which I hope to be able to supply in the future."—*Phil. Mag.*, No. 62, 1906, pp. 206–226.

J. T.

8. *Spark Potentials.*—Various observers have compiled tables of such values for the information of electrical engineers. M. Toepler gives the following table as the result of recent investigation.

Sparking distance in cm.	5	10	15	20	25	30	35	40	45
Kilovolt observed	31·6	46·6	63·1	78·9	94·6	112·2	125·1	139·1	153·8
Kilovolt calculated by Walter ...	31·6	47·1	62·7	78·2	93·8	109·3	124·9	140·4	156·0
Kilovolt calculated by Toepler ...	27·97	46·38	63·20	79·24	94·75	109·88	124·73	139·38	153·82

—*Ann. der Physik*, No. 1, 1906, pp. 191–209. J. T.

9. *Measures of Radiation in relation to Resonators in the Region of Short Electric Waves.* — It has been noticed by F. Kirchener that the optical properties of Lippeman's emulsion are changed when the emulsion is moistened ; and he explains this by the supposition that the swimming silver particles act as electrical resonators and that their time of vibration is changed by the increase of distance apart. M. PAETZOLD has studied the effect of gratings interposed between the electrical exciter and receiver of short electrical waves, guided by the analogy conceived by Kirchener. The gratings were placed at various distances from the receiver and at different angles. When a strait rod exciter was used to produce the waves, a wave component was discovered in a plane perpendicular to the exciter which differed 90° in phase from the ordinary component. The effect of a grating in certain positions is to produce often a combined effect of received and emitted radiations.—*Ann. der Physik*, No. 1, 1906, pp. 116–137. J. T.

10. *Electrical Rectifier.*—In previous papers A. WEHNELT has described a rectifier for alternating currents which serves the purpose of the Cooper Hewitt mercury rectifier, or the Gratz aluminium rectifier. The cathode is covered with certain oxides which greatly diminish the cathode fall of potential. Such an electrode he terms oxide electrode. When this oxide electrode is properly heated and made the cathode, the difference of potential can be made only 18·20 volts, while if the neighboring cold anode is made the cathode, the potential rises to many thousand volts. The electrical current, therefore, will pass readily in one direction and with great difficulty in the opposite direction. Wehnelt ascribes the performance of the rectifier to an increase of ionization at the oxide electrode.—*Ann. der Physik*, No. 1, 1906, pp. 138–156. J. T.

II. GEOLOGY AND MINERALOGY.

1. *United States Geological Survey. Twenty-sixth Annual Report, 1904–1905, of the Director*, CHARLES D. WALCOTT. 322 pp., 26 maps.—The volume contains besides the executive and financial statements brief reports from the chiefs of parties upon the scientific results of the year's work. The three great branches of work carried on by the Survey are the geologic, topographic and hydrographic. Connected with the latter is the Reclamation Service, by means of which considerable tracts of arid land will ultimately be brought under cultivation.

It is of interest to note the amount of the appropriations to the several divisions, as these are in some measure indicative of the lines along which the work of the Survey is being at present chiefly pushed. The entire appropriation aggregated $1,484,820, of which 309,200 was assigned for topographic work, 188,700 for geologic work, 14,000 for paleontologic work, 23,000 for chemical work, 200,000 for gauging streams, 50,000 for preparation of report

on mineral resources, 130,000 for survey of forest reserves. The preparation and printing of maps and reports also aggregates a large amount. In addition 80,000 was appropriated for continuation of the investigation of the mineral resources of Alaska and 60,000 for testing coals.

Among the many interesting results of the year's work may be singled out the finding on Cape Lisburne of 15,000 feet of Jurassic strata containing 150 feet of Jurassic coal distributed in over forty beds, at least ten of which are four feet or more in thickness, the first Jurassic coal to be found in Alaska. In addition the Carboniferous was found to contain some coal, being the only Paleozoic coal of economic value known in America west of the Rocky Mountains. The coal and petroleum deposits about Controller Bay have also been found to be of importance.

Under the subject of topography it is noted that the total area of new surveys was 21,296 miles, making a total of 955,996 miles surveyed, or 32 per cent of the area of the United States. Those familiar with the maps will have noticed the improved quality of those issued in recent years.

Sixteen folios, forming Nos. 110 to 125 of the geological atlas of the United States, have been published during the past year.

In the investigation of the mineral wealth of the United States and the education of the mining public in regard to the nature of economic deposits with consequent economization of time and money in their exploitation, the Survey has justified itself many times over; but its chief claim for world-wide recognition is founded on the more purely scientific work done, which in the past quarter century has contributed either directly or indirectly more than any other one factor toward the advances of modern geology. J. B.

2. *U. S. Geological Survey. Recent Publications.*—The following list contains the titles of recently issued publications.

Topographic Atlas.—Ninety-nine sheets.

Folios—No. 127. Sundance Folio: Wyoming–South Dakota. Description of the Sundance Quadrangle: by N. H. Darton. Pp. 12, with 5 colored maps and 9 figures.

No. 128.—Aladdin Folio: Wyoming–South Dakota–Montana; by N. H. Darton and C. C. O'Harra. Pp. 8, with index map and 4 colored maps. Washington: 1905.

No. 129.—Clifton Folio: Arizona; by Waldemar Lindgren. Pp. 13, with 4 colored maps.

Professional Papers.—No. 37. The Southern Appalachian Forests; by H. B. Ayres and W. W. Ashe. Pp. 291, with 37 plates, two figures, and two colored maps.

No. 40.—The Triassic Cephalopod Genera of America; by Alpheus Hyatt and James Perrin Smith. Pp. 394, with 85 plates and one figure.

No. 43.—The Copper Deposits of the Clifton-Morenci District, Arizona; by Waldemar Lindgren. Pp. 375, with 25 plates, 19 figures, and one colored map.

Mineral Resources of the United States. Calendar year 1904; by DAVID T. DAY, Chief of Division of Mining and Mineral Resources. Pp. 1264, with two plates.

BULLETINS. — No. 265. Geology of the Boulder District, Colorado; by N. M. FENNEMAN. Pp. 101; v, with 5 plates and 11 figures.

No. 268.—Miocene Foraminifera from the Monterey Shale of California; by RUFUS M. BAGG, JR. Pp. 78; v, with 9 plates and two figures.

No. 270.—The Configuration of the Rock Floor of Greater New York; by WILLIAM HERBERT HOBBS. Pp. 96; v, with 5 plates and 6 figures.

No. 272.—Taconic Physiography; by T. NELSON DALE. Pp. 49; III, with 14 plates and 3 figures.

No. 273.—The Drumlins of Southeastern Wisconsin (Preliminary Paper); by WILLIAM C. ALDEN. Pp. 43; III, with 9 plates and 8 figures.

No. 276. — Results of Primary Triangulation and Primary Traverse, Fiscal year 1904–5; by SAMUEL S. GANNETT. Pp. 263; III with 1 plate.

WATER SUPPLY AND IRRIGATION PAPERS. — No. 123. Geology and Underground Water Conditions of the Jornada del Muerto, New Mexico; by CHARLES ROLLIN KEYES. Pp. 42; V, with 9 plates and 11 figures.

No. 137.—Development of Underground Waters in the Eastern Coastal Plain Region of Southern California; by WALTER C. MENDENHALL. Pp. 140; III, with 7 plates and 6 figures.

No. 138.—Development of Underground Waters in the Central Coastal Plain Region of Southern California; by WALTER C. MENDENHALL. Pp. 162; III, with 5 plates and 5 figures.

No. 139. — Development of Underground Waters in the Western Coastal Plain Region of Southern California; by WALTER C. MENDENHALL. Pp. 103; III, with 8 plates and one figure.

No. 140.—Field Measurements of the Rate of Movement of Underground Waters; by CHARLES S. SLICHTER. Pp. 119; III, with 15 plates and 67 figures.

No. 142.—The Hydrology of San Bernardino Valley, California; by WALTER C. MENDENHALL. Pp. 124; III, with 12 plates and 16 figures.

No. 147.—Destructive Floods in the United States in 1904; by EDWARD CHARLES MURPHY AND OTHERS. Pp. 206; II, with 18 plates and 19 figures.

No. 150.—Weir Experiments, Coefficients and Formulas; by ROBERT E. HORTON. Pp. 189; I, with 38 plates and 16 figures.

No. 151.—Field Assay of Water; by MARSHALL O. LEIGHTON. Pp. 76; III, with 4 plates and 3 figures.

No. 152.—A Review of the Laws Forbidding Pollution of Inland Waters in the United States. Second edition; by EDWIN B. GOODELL. Pp. 149; III.

3. *The Triassic Cephalopod Genera of America;* by ALPHEUS HYATT and JAMES PERRIN SMITH. Prof. Papers, No. 40, U. S. Geol. Surv., 1905, 214 pp., 85 pls.—This extensive monograph of marine Triassic cephalopod genera is practically the work of the junior author, "but the inspiration and general supervision of the work was [the late] Professor Hyatt's contribution." "In this work every genus of cephalopods known to occur in American Triassic strata is described, and a representative species under each one is described and figured."

The marine Triassic development of Idaho, Nevada, Oregon, and California is unusually complete. The lower (800′), middle (1000′), and upper (2000′) members "are represented by calcareous deposits, aggregating approximately 4,000 feet in thickness." In addition to a summary statement of the various sections and their cephalopod species, this work defines in detail 85 genera (20 new) and 88 species (66 new). For many of the species the stages of growth are also described. Of the genera, 80 are Ammonoidea, 1 belongs to the Belemnoidea, and 4 are Nautiloidea. Of the ammonoid genera, 22 are restricted to western North America; the rest are also found either in Europe or Asia. Fifteen are common to America and Asia, 10 to Europe and America, and 33 to the three regions. Of species, 7 ammonoids and 1 nautiloid are common to the Alps and America.

From these statements, it is seen that the ammonoids are very widely distributed, and as early as Triassic time are, as is well known, likewise excellent horizon markers, not only for closely adjoining regions, but also for inter-continental correlations.

This work is of great value, not only to the student of the Ammonoidea, but as well to the stratigrapher of Triassic formations. C. S.

4. *Miocene Foraminifera from the Monterey Shale of California;* by RUFUS M. BAGG, Jr. Bull. No. 268, U. S. Geol. Surv., 1905, 55 pp., 11 pls.—The Monterey shale is from 2000 to 2500 feet thick. The bulk is made up of diatom skeletons, but there is also present an abundance of well-preserved Foraminifera. The clay marl of Graves Creek, San Luis Obispo County, has yielded a fauna of 66 species in 17 genera. There are no arenaceous genera, warm-water Miliolidæ, and but one Nummulite, but a large number of rotaline types are present. This faunal composition, the author states, "shows the purity of the waters in oceanic circulation," and less than 500 fathoms deep. Most of the species are those of living forms. The illustrations are excellent. C. S.

5. *North Carolina Geological Survey. Vol. I, Corundum and the Peridotites;* by J. H. PRATT and J. V. LEWIS. 8°, pp. 464, pl. xlv, figs. 35. Raleigh, 1905.—This volume presents very fully the geology, petrology and mineralogy of the belt of corundum-bearing rocks of western North Carolina. The peridotites and associated basic magnesian rocks are first taken up and the

various occurrences in the state are described with the aid of maps, sections and illustrations. Then follows a complete petrographic study of these rocks accompanied by many analyses. Their modes of alteration and decomposition and their origin are discussed, and this is succeeded by a mineralogical description of the North Carolina corundum together with an account of its technical properties and uses. The authors then describe its modes of occurrence in this region and elsewhere, following this with a statement of its distribution. Next comes a chapter devoted to the alteration of corundum and a study of the minerals associated with it, which contains a large amount of detailed observations upon many species. The work is concluded with an account of the chromite and other economic minerals of the peridotitic rocks of the region.

While a considerable part of the matter here given has, in more or less condensed form, been previously published elsewhere, especially in this Journal, the rest of it is new and the whole thus collected forms a most valuable compendium of the peridotitic rocks of the region and their associated minerals. As such it is, not only of local, but of general interest and will prove of service to the mineralogist, the petrographer and the economic geologist. The volume is well printed and illustrated and is a handsome specimen of the bookmaker's art. L. V. P.

6. *Cancrinite-Syenite from Kuolajärvi;* by I. G. SUNDELL. Bull. Comm. Geol. de Finlande, No. 16, 1905, 20 pp.—The author has analyzed this rare and interesting rock type previously described by Ramsay and Nyholm (Ibid., No. 1, 1895), and the results of the work, which has been carried out in detail with great care, are as follows:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	
52·25	20·46	3·82	0·68	0·14	2·39	10·05	6·18	1·83	1·69	0·32	= 100·15

This includes traces, or minute quantities, of ZrO_2, NiO, MnO, SrO, BaO, P_2O_5 and SO_3, which total 0·34. The low silica and very high alkalies are notable. The calculation of the mineral composition shows that it contains nearly 27 per cent of cancrinite. L. V. P.

7. *Opal Pseudomorphs from White Cliffs, New South Wales;* by C. ANDERSON and H. STANLEY JEVONS.—The authors offer the latest explanation of these interesting pseudomorphs which in recent years have engaged the attention of a number of mineralogists. They show that the original mineral must have been monoclinic, with a good cleavage perpendicular to the symmetry plane, with certain interfacial angles and characterized by a certain geological mode of occurrence. It could not, therefore, have been either gypsum, sulphur, anhydrite or celestite, and the writers believe that glauberite, the sulphate of soda and lime, most nearly fills the required conditions and was the original mineral. (Records Austr. Mus., vol. vi, Pt. I, pp. 31–37, 1905.)

L. V. P.

8. *The Physical Geography, Geology, Mineralogy and Paleontology of Essex County, Massachusetts;* by JOHN HENRY SEARS. 1905, pp. 418, figs. 209, map in pocket. Salem, Mass. (Published by the Essex Institute.)—The region described in this handsome volume is both interesting and exceptionally varied from the geological point of view, especially as regards its igneous rocks and glacial geology. The author's intimate acquaintance with the county, based on many years of residence and study, renders his exposition detailed and authoritative. The numerous good illustrations are mostly from photographs, the type and paper irreproachable, and the publication is a valuable contribution to the geology of the Eastern States and highly creditable alike to its author and to the Essex Institute. H. S. W.

9. *Lead and Zinc Deposits of Virginia;* by THOMAS L. WATSON. Geol. Survey of Virginia, Geol. Series Bulletin, No. 1. Pp. 156 with 14 plates and 27 figures, 1905.—This is an interesting account of the important lead and zinc deposits of Virginia, with a discussion on the genesis of the ores and the methods employed in mining and smelting. The lead and zinc mines group themselves into two divisions: (1) those of southwest Virginia limited to the Great Valley region and (2) those of the crystalline belt, or Piedmont region, east of the Blue Ridge mountains; almost all the ore production has been from the former region. The estimated annual output from the Virginia mines, from 1894 to 1903, is given as not exceeding 15,000 tons; the minerals forming the bulk of this are smithsonite and calamine.

10. *Asbestos: its Occurrence, Exploitation, and Uses;* by FRITZ CIRKEL, M.E. Pp. 169, with 19 plates. Ottawa, 1905. Mines Branch, Department of the Interior.—The asbestos industry of Canada, which had its beginning in 1877, has now attained such magnitude that this monograph on the subject is of particular interest. The author states that there are now sixteen mills, with a capacity of 3500 tons per day, in active operation and that there is every prospect of this output being largely increased in the course of the present year.

Of the two mineral species included under this name, the only one which has any importance in Canada and the one which has proved to be much the more useful in application to the arts, particularly because of its relative strength of fiber, is the fibrous variety of serpentine, called chrysotile. The fibrous variety of amphibole, corresponding mostly to tremolite and in part to actinolite, while mined to some extent in Italy and elsewhere, and occurring in Hastings County, Ontario, has proved to be of much less importance. Fibrous serpentine occurs in the Laurentian formation, in the Templeton area, north of Ottawa, in connection with serpentinous limestone, and also in the eastern townships in the Province of Quebec. Deposits in the former area have been to some extent exploited, but without any great success. The region in which active work has been carried on now for nearly thirty years is that south of Quebec, including Thet-

ford, Black Lake area, and the Danville, Orford and Potton area not far distant to the southwest. The serpentines here are disconnected masses, generally of small extent, in the series of slates, schists and diorites designated as a part of the Cambrian. Serpentine also occurs extensively in the Gaspé Peninsula, but this region has not been developed to any considerable extent. A full account is given in this volume of the separate mines and the methods of working them; the various commercial purposes to which asbestos can be applied are also explained at length. It is now found possible to spin asbestos threads so that one, for example, weighing not more than an ounce per hundred yards, has a fair degree of strength. Asbestos cloth and rope are extensively made, and the material is also used for roofing and numerous other purposes, most of them equally familiar.

11. *The Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming;* by WILLET G. MILLER, Provincial Geologist. Pp. 66. Toronto: L. K. Cameron, 1905. Report of The Bureau of Mines, 1905. Part II. Thomas W. Gibson, Director.—The remarkable development of the nickel industry in Canada lends interest to this report of a new deposit of cobalt-nickel arsenides and silver, discovered during the year 1904, during the building of the Temiskaming and Northern Ontario Railway. The minerals identified are native silver, smaltite, niccolite and chloanthite, and associated with these several silver and cobalt minerals of rarer occurrence. The veins are narrow, some 10–12 inches in width, and the ore from the silver-bearing veins is stated to contain 11·4 per cent of silver, 11·3 per cent of cobalt, while that from the veins not carrying silver shows 15·6 per cent of cobalt and 7·0 per cent of nickel. The veins occupy vertical cracks and fissures, cutting across the slightly inclined conglomerate slate series of the Lower Huronian.

12. *Economic Geology of the United States;* by HEINRICH RIES; 435 pp., 25 pls., 97 figs. New York, 1905 (The Macmillan Company).—This recent publication by Professor Ries of Cornell University is another indication of the increasing consideration given to Economic Geology as an important department of the general subject of geology. An elementary text-book for class room use was greatly needed in this subject and the present book admirably fills that need. The book is about equally divided into two parts: Part I treats of non-metallic minerals and includes, besides others, chapters on coal, petroleum, etc., on building stones, clay, lime and cements, on salines, gypsum, fertilizers, and abrasives; Part II discusses the metallic minerals and, besides a chapter of general discussion on the subject of ore bodies and their formation, includes chapters which in turn treat of the occurrences of the important metals. The book is well and profusely illustrated with maps, geological sections, tables and half-tone engravings. A valuable feature is the long list of references which is given at the end of each chapter and which includes all the important papers dealing with the subject of the chapter.

W. E. F.

13. *Handbuch der Mineralogie;* von Dr. Carl Hintze. Erster Band. Elemente, Sulphide, Oxyde, Haloide, Carbonate, Sulfate, Borate, Phosphate. Neunte Lieferung. Pp. 1281–1440, with 30 figures. Leipzig, 1905 (Von Veit & Comp.).—The successive issues of Hintze's monumental work are always welcome even if they appear only at long intervals. The present part is entirely devoted to the species of quartz.

III. Miscellaneous Scientific Intelligence.

1. *Reports on the Scientific Results of the Expedition to the Eastern Tropical Pacific in charge of Alexander Agassiz, by the U. S. Fish Commission "Albatross," from October, 1904, to March, 1905, Lieut. Commander L. M. Garrett, U. S. N., commanding.*

General Report of the Expedition by Alexander Agassiz. Published as vol. 33, Memoirs of the Museum of Comparative Zoology at Harvard College. Cambridge, 1906, 75 pp., 96 plates and eight figures in the text.—The area selected for this cruise of the "Albatross" included the vast tract of the Eastern Pacific, some 3000 miles in latitude by 3500 in longitude, between Acapulco, the Galapagos Islands, Callao, Easter Island and Manga Reva, the easternmost of the Paumotu or Low Archipelago. The survey consisted in running lines between these points. There is no other oceanic area situated at so great a distance from a continental area and interrupted by so few islands.

But little was previously known of the hydrography of this area, only a few casual deep-sea soundings having been previously taken far from land. The biological material is now in the hands of specialists, but among the results already evident may be mentioned the localized extension of the abyssal oceanic fauna far from shore and its dependence upon the pelagic food derived by settling from the photobathic zone or brought to it by the great oceanic currents. Over an immense tract south of the Humboldt current running from near the Low Archipelago to within about ten degrees of the South American coast, the whole of the bottom area is barren of animal life and forms a great desert upon which drop the carcasses of a poor pelagic area.

Turning to the soundings, it is noted that 160 were taken, the Lucas sounding-machine being used, or about one per day, distributed over a distance of about 13,000 miles. The area is comparatively shallow, varying generally from 1800 to 2300 fathoms. The survey served to delimit the Albatross Plateau, named by the Challenger expedition, and to separate a new basin, named the Bowers Basin, lying off Callao, from the indefinitely known Buchan Basin located by the Challenger expedition.

This expedition has added a great deal of definite knowledge to the oceanography of this area: an inconsistency in the bathymetrical chart, Plate I, must however be noted, the Moser Deep and the Grey Deep being separated by a *single* 2500 fathom contour line. This inconsistency further results in the Moser Basin

being delimited by a 2500 contour line and lying within a much larger basin also bounded by a 2500 line. This region, however, lies outside of the present survey.

Plates 15 to 91 are most excellent reproductions, by the Heliotype Printing Company, from photographs of Sola y Gomez and Easter Islands, the Gambier Islands and Chatham Island. These give a good scenic idea of these little known lands and will be valuable for future reference. Numerous photographs of the stone effigies of Easter Island are also given. It must be said, however, that but little use has been made of many of the views in this report, some being of minor scientific value and repetitions being embodied of the same general landscape from slightly different points of view. It is realized that the time spent at these islands in coaling was brief and that land geology was not an object of the expedition. Nevertheless this part of the report would have been much improved by a fuller interpretation of the physiography of the lands represented, with possibly sketches to aid in interpreting certain of the photographs.

It is noticeable that the topography of Easter Island is very much softened, except in the case of a few of the craters, notably Rana Kao, 1327 feet high. The Gambier Islands, on the contrary, as noted by Agassiz, show a greater degree of dissection and especially many precipitous slopes, cliffs of 800 to 1300 feet rising within a horizontal distance of an eighth to a quarter of a mile. One of the most striking features however, as seen in the photographs, is a horizontal bench on the sides of Mount Duff at an elevation of from 300 to 325 feet above the sea (see plates 57 and 64). This has all the appearance of an old sea beach facing a cliff a thousand feet in height, but no mention is made of it in the report. J. B.

2. *Carnegie Institution of Washington. Year Book, No. 4*, 1905. Pp. VIII, 303, with 7 plates and 4 figures. Washington: 1906.—The Fourth Year Book of the Carnegie Institution contains the usual statement in regard to the work that has been carried forward through the year, and gives also brief reports and abstracts of investigations that are now under way. During the year 1904–5 upward of $300,000 were devoted in large grants to important investigations in eleven different subjects, and $130,000 to about forty investigations of a minor grade. The Executive Committee has reached the conclusion that the policy of awarding numerous small grants is likely to break down in consequence of the importunities of those seeking them and the difficulty of the work of administration; further such awards are regarded as, in general, not for the real benefit of the educational institutions concerned. On the contrary, the larger grants are not thus open to criticism and they seem to be those for which the available income can be most advantageously devoted. Of new projects under consideration are mentioned: an Astronomical Observatory in the Southern Hemisphere, and a Laboratory for Geophysical research at Washington. There can be no question but that the decision of the management is

wise in thowing the chief benefits of this fund in the directions named.

The following are recent publications: No. 38.—Writings on American History: 1903. A Bibliography of Books and Articles on United States History published during the year 1903, with some Memoranda on other Portions of America, prepared by A. C. McLaughlin, W. A. Slade, and E. D. Lewis. Pp. 172.

No. 42.—A Respiration Calorimeter with Appliances for the Direct Determination of Oxygen; by W. O. Atwater and F. G. Benedict. Pp. 193, with 49 figures.

No. 45.—Catalogue of Stars within Two Degrees of the North Pole, reduced from Photographic Measures made at Vassar College Observatory; by Caroline E. Furness, Ph.D. Pp. 85, with 16 tables.

3. *Report of the Secretary of the Smithsonian Institution for the year ending June 30, 1905;* by S. P. Langley.—The functions of the Smithsonian Institution are so varied and important that much interest attaches to the advance Report giving a statement of what has been accomplished by the Smithsonian Institution during the year ending June 30, 1905. In addition to the work upon the new Museum, which is progressing steadily, a mortuary chapel has been constructed to contain the tomb of James Smithson, whose remains were brought from Italy in January, 1904. Of the work done outside of Washington may be mentioned the archeological exploration of Dr. Fewkes in Mexico, the expedition to Alaska by Mr. A. G. Maddren and the glacier expedition on the Canadian Rockies and Selkirks under the direction of Prof. W. H. Sherzer. As usual, the Astrophysical Observatory has carried on some important investigations, particularly in the measurement of solar radiation; in regard to this, Mr. C. G. Abbot remarks: "The work of this and the two preceding years strongly supports the view that the radiation of the sun is frequently diminished and augmented for periods of a few weeks or months, in consequence of a variability of the transparency of the solar absorbing envelope, and that this variation of radiation causes and quickly produces changes of several degrees in the mean temperature of the land areas of the earth. It is hoped that the study of the solar radiation will soon prove a valuable aid in forecasting climate.

4. *Report of the Superintendent of the Coast and Geodetic Survey, showing the Progress of the Work from July 1, 1904, to June 30, 1905;* by O. H. Tittmann. Pp. 347, with 8 illustrations.—This volume gives the usual summary of the work of the Survey during the year, including what has been done in the outlying dependencies, especially in the Philippines. These results are summarized by the superintendent in the opening chapter, and discussed in detail in the appendixes which follow. The most noteworthy result accomplished is the completion of the line of precise levels connecting the Atlantic Ocean at Sandy Hook and the Gulf of Mexico at Biloxi, Miss., with the Pacific

Ocean at Seattle. Appendix III contains an account of magnetic observations made under the charge of Dr. L. A. Bauer; this special report has also been issued in separate form. It is stated that there have now been obtained exact magnetic data for determining the distribution of the magnetic elements and their secular change throughout the United States, so that a new set of charts may soon be expected for the year 1905. In regard to the secular change of magnetic declination, it is noted that at present the line of no annual change does not differ much from the agonic line, and that in general both the east and west declination are increasing.

5. *Publications of the United States Naval Observatory.* Rear Admiral Colby M. Chester, U. S. N., Superintendent. Second series. Volume IV, Appendix I. Pp. 307, with 69 plates. Washington, 1905.—This important volume is devoted to a discussion of the total solar eclipses of May 28, 1900, and May 17, 1901. The plates representing the corona, both from photographs and drawings, are most interesting.

6. *Bureau of American Ethnology.*—The following publications have been recently received:

Twenty-third Annual Report of the Bureau of Americal Ethnology to the Secretary of the Smithsonian Institution 1901–1902. Pp. xlv, 634. Washington, 1904.

Bulletin No. 28: Mexican and Central American Antiquities, Calendar Systems, and History. Twenty-four papers by Eduard Seler, E. Förstemann, Paul Schellhas, Carl Sapper, and E. P. Dieseldorff; translated from the German under the supervision of Charles P. Bowditch. Pp. 682, with 48 plates and 134 figures. Washington, 1904.

Bulletin 29: Haida Texts and Myths, Skidegate Dialect; recorded by John R. Swanton. Pp. 448, with 5 figures. Washington, 1905.

7. *Bulletins of the United States National Museum.* No. 54. —A Monograph on the Isopods of North America; by Harriet Richardson. Pp. liii; 727, with 740 figures.

No. 55.—A Contribution to the Oceanography of the Pacific; by James M. Flint. Pp. 61, with 12 plates.

8. *Mazama: A Record of Mountaineering in the Pacific Northwest.* Vol. 2, No. 4. December, 1905. Pp. 284.—The Annual Number of "Mazama," published in December, 1905, contains several valuable and well illustrated articles on the high peaks of the northwest, particularly as regards their glaciers. Detailed views are given of ice pinnacles on Mt. Hood, and the various features of the ice and snow of Mt. Ranier. These descriptions have much more than a local interest.

9. *Elementary Mechanics;* by George A. Merrill, B.S., Director of the Wilmerding School of Industrial Art, San Francisco. Pp. 267. New York, 1905 (The American Book Co.).—The usual topics treated in a work of this character are here presented with much clearness and freshness. The author relies on illustrations and numerical applications to the exclusion of all formal proofs. The numerical exercises are well chosen but limited in number.

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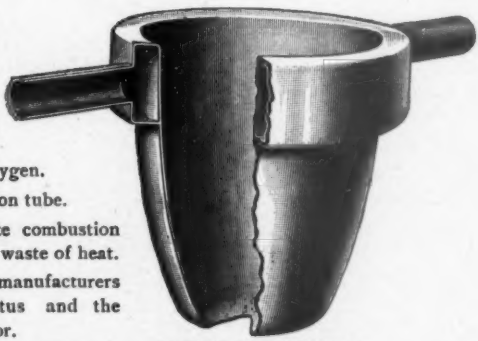

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